COMMUNICATIONS

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APRIL ★ AUDIO PROBLEMS IN A-M BROADCASTING ★ EMERGENCY COMMUNICATIONS EQUIPMENT 1947

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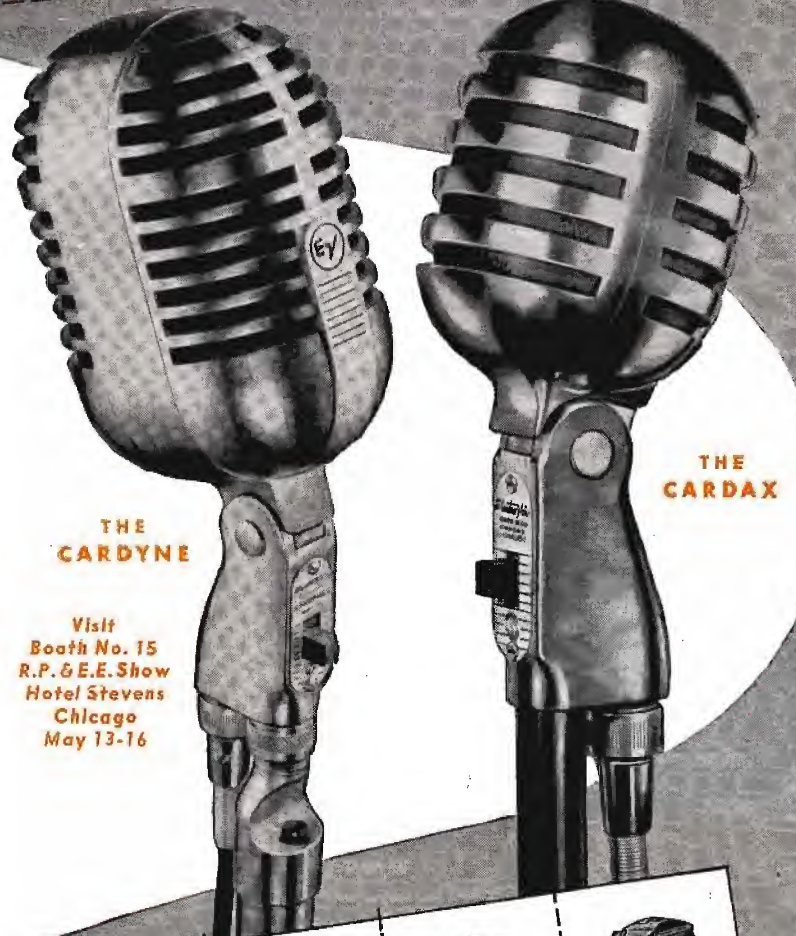

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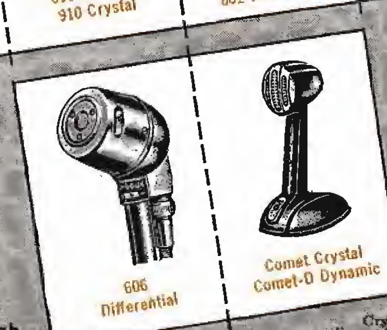

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APRIL, 1947 **VOLUME 27** **NUMBER 4**

COMMUNICATIONS

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COVER ILLUSTRATION

C. Miller Sanford, assistant project engineer of Bendix Radio, adjusting a v-h-f railroad radio pack set designed to provide track-side communications in end-to-end operation.

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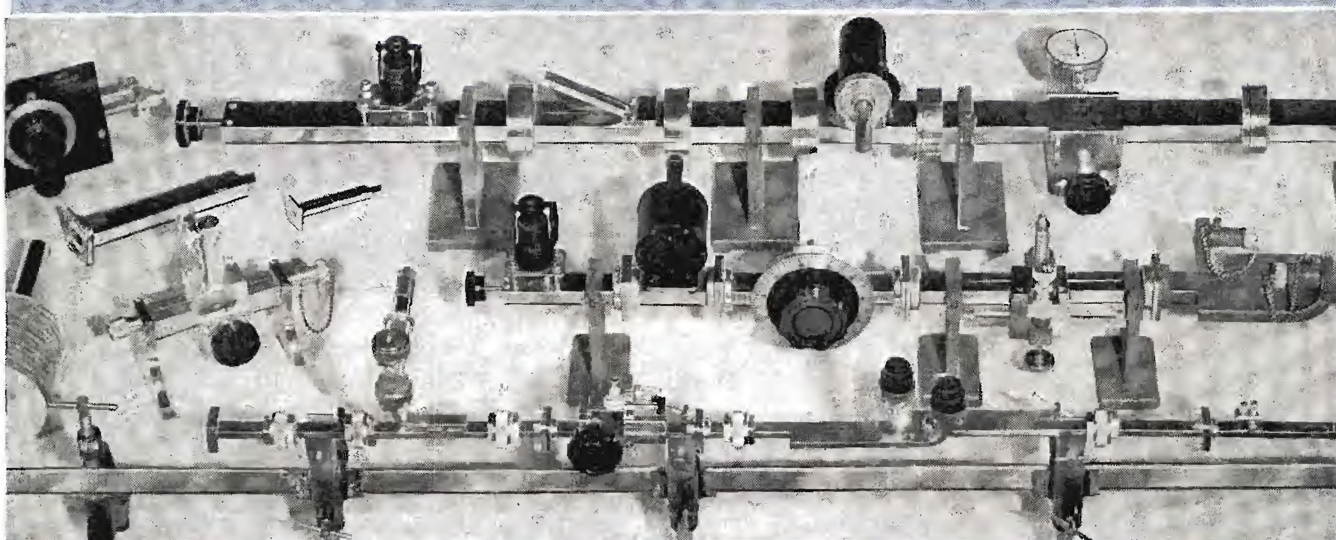

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EIMAC 4-750A POWER TETRODE Electrical Characteristics	
Filament: Thoriated tungsten	
Voltage	7.5 volt
Current	20 amp
Direct Interelectrode capacitances (av.)	
Grid-plate	.24 μμf
Input	26.85 μμf
Output	7.78 μμf
Maximum Ratings	
D-C Plate Voltage	6000 max. volts
D-C Plate Current	700 max. ma.
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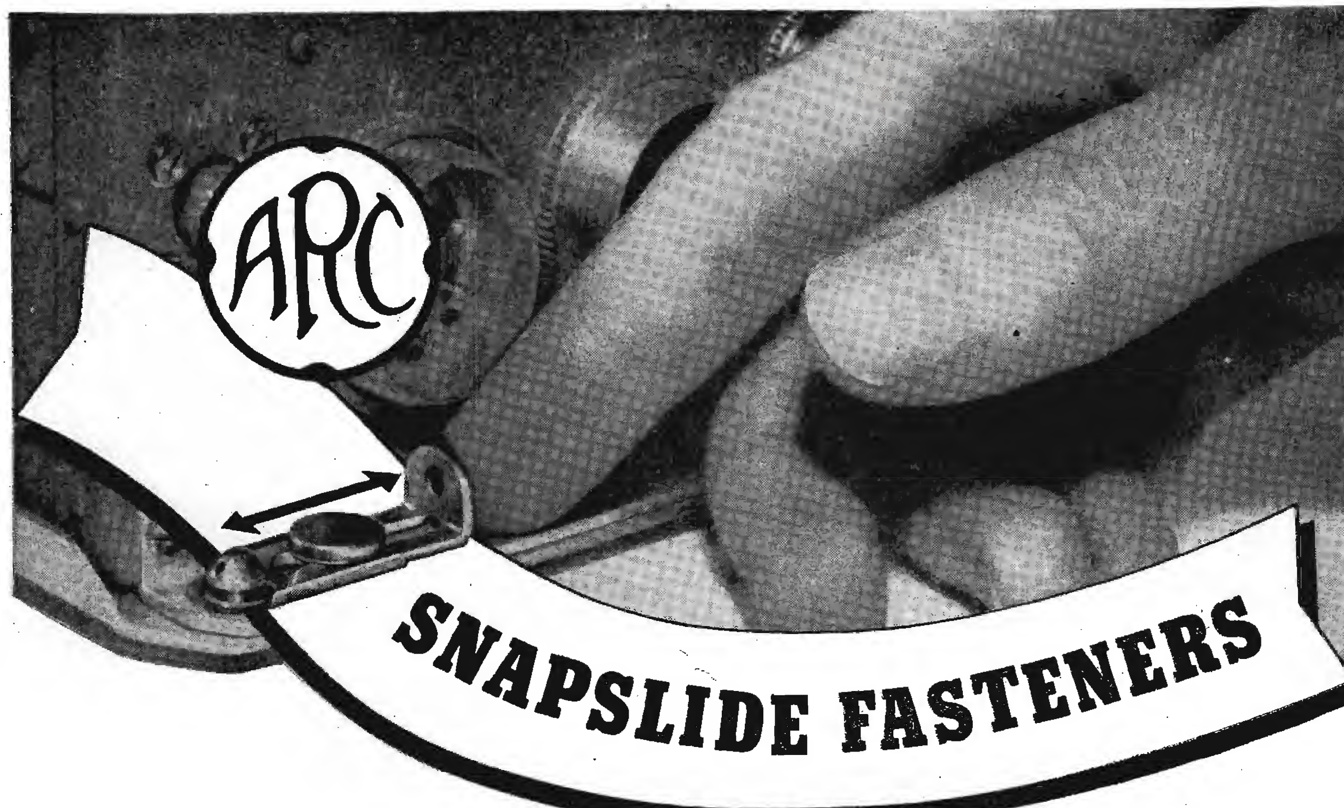

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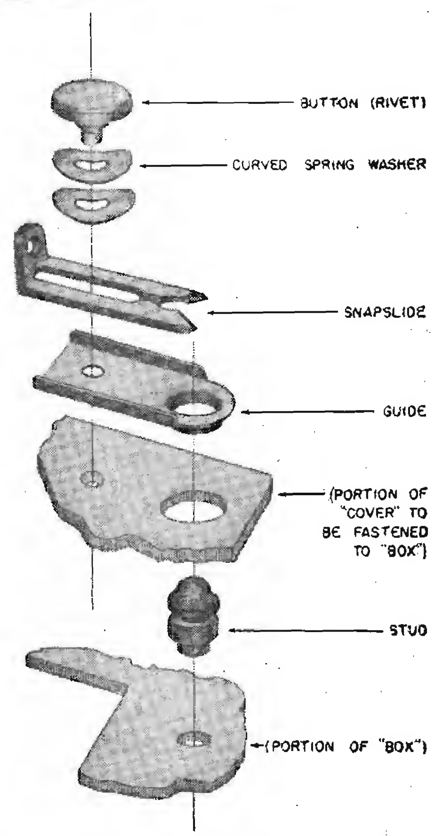

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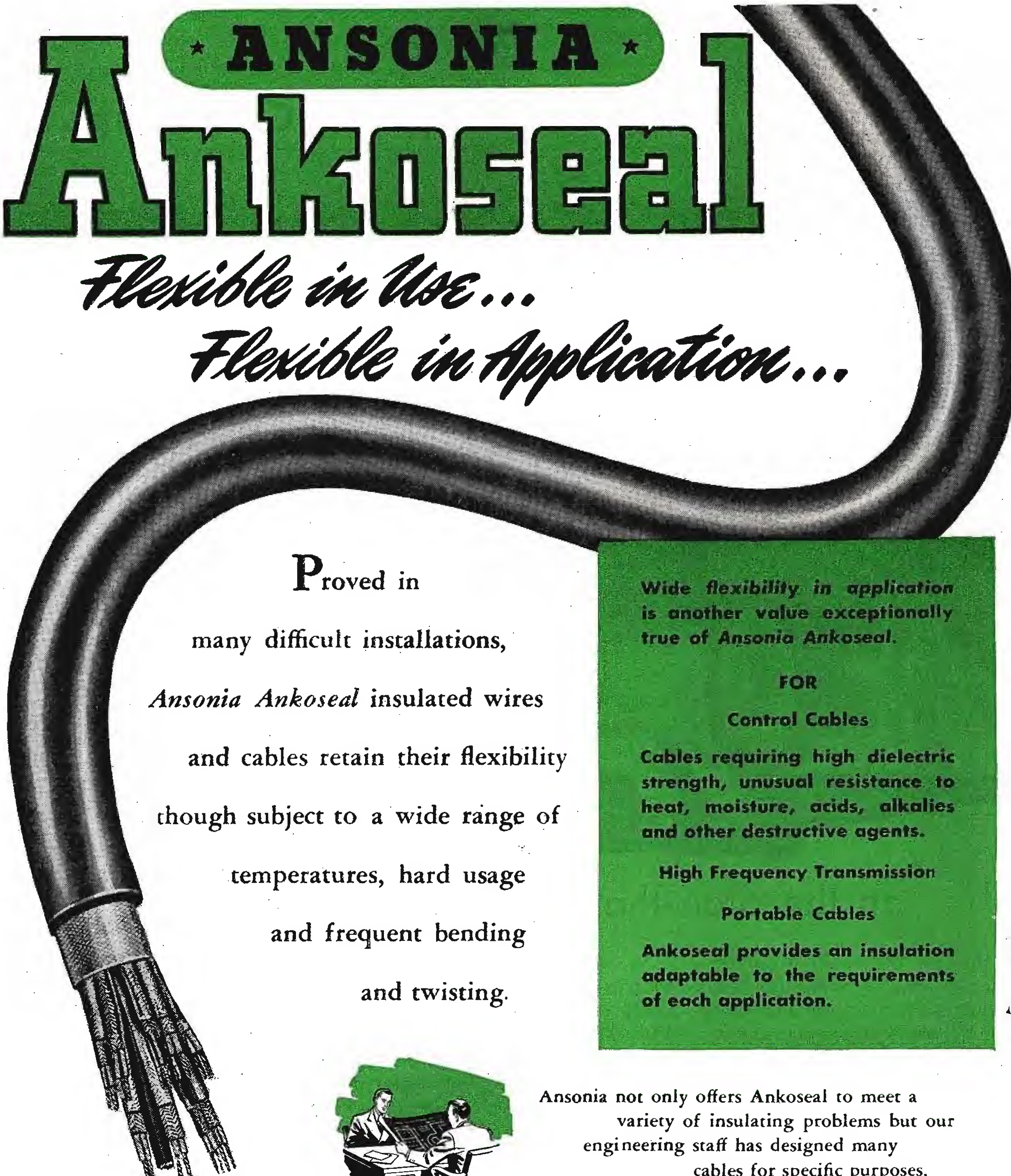

Proved in many difficult installations, *Ansonia Ankoseal* insulated wires and cables retain their flexibility though subject to a wide range of temperatures, hard usage and frequent bending and twisting.

Wide flexibility in application is another value exceptionally true of Ansonia Ankoseal.

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Cables requiring high dielectric strength, unusual resistance to heat, moisture, acids, alkalies and other destructive agents.

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BEAM POWER TETRODE WITH ELECTRONIC GRAPHITE ANODE

First of Sylvania's new line of transmitting tubes, the 3D24 is a four-electrode amplifier and oscillator with 45 watt anode dissipation. An outstanding development is the electronic graphite anode, which allows high plate dissipation for small area and maintains constant inter-element relationship and uniform anode characteristics.

The 3D24 may be used at full input up to 125 Mc — maximum permissible frequency will be announced later upon completion of tests.

OTHER FEATURES INCLUDE:

1. **Lock-In base.** Short leads, no soldered joints.
2. **Top cap** providing for short path, greater cooling by radiation and convection, resulting in a cooler seal.
3. **Thoriated tungsten filament,** giving high power output per watt of filament power.
4. **Vertical bar grids.** #1 grid supplied with two leads for better high frequency performance. #2 grid provided with heat-reflecting shield for greater dissipation, low grid-plate capacity.
5. **Low interelectrode capacity.** No neutralizing needed with proper circuit arrangement.
6. **Hard glass envelope.** Permits high power for small size.

The 3D24, a product of the Electronics Division of Sylvania, has interesting potentialities in amateur, police, mobile and marine radio.

MECHANICAL SPECIFICATIONS

Type of cooling	Air—radiation and convection
Mounting position	Vertical, base down or up
Length overall	4.3 inches max.
Seated height	3.769 inches
Diameter	1½ inches
Net weight	1.3 ounces

ELECTRICAL CHARACTERISTICS

Filament Voltage	6.3 volts
Filament Current	3.0 amperes
Amplification Factor	50
Direct Interelectrode Capacitances	
Grid-Plate	0.2 $\mu\mu f$ max.
Input	6.5 $\mu\mu f$
Output	2.4 $\mu\mu f$

3D24 TYPICAL OPERATING CONDITIONS

R. F. Power Amplifier and Oscillator — Class C Telegraphy

Characteristic	C.C.S.	C.C.S.
D. C. Plate Voltage	1500 volts	2000 volts
D. C. Control Grid Voltage	−300 volts	−300 volts
D. C. Screen Grid Voltage	375 volts	375 volts
D. C. Plate Current	90 ma	90 ma
D. C. Control Grid Current	10 ma	10 ma
D. C. Screen Grid Current	22 ma	20 ma
Peak R. F. Grid Input Voltage	400 volts approx.	400 volts approx.
Full Driving Power	4.0 watts approx.	4.0 watts approx.
Plate Power Output	105 watts	140 watts

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5-5-47

COMMUNICATIONS

LEWIS WINNER, Editor

APRIL, 1947

THE FCC "NO" TO COLOR TV:

Many sturdy factors contributed to the FCC negative tv color-standards decision. The solidarity of industry opposition developed in the RMA report, of course, was an important swaying item. But the engineering testimony offered by such experts as Dr. G. H. Brown on antennas was particularly significant and made a deep impression with the Commission.

In his antenna comment, Dr. Brown stated . . . "Since a small dipole at 490 mc will produce a voltage on the transmission line 17 db lower than the voltage produced on the transmission line by a half-wave dipole at 67.25 mc, it would be necessary to use a receiving antenna with a power gain of 50 at 490 mc to achieve equal voltages on the transmission line at the two frequencies. . . . A power gain of 50 at 490 mc calls for a receiver antenna with an aperture at least 5 feet wide and 5 feet high. . . . The effective aperture or capture area of a half-wave dipole at 67.25 mc is approximately 25 square feet. Hence, to obtain the same voltage on a transmission line at 490 mc, we must use the same area for the directive antenna, and if we go to 900 mc we must again use an antenna with an aperture of at least 5 feet on the side. . . . I am of the opinion that a receiving antenna with an effective area of 25 square feet will not be looked on with favor by the purchaser of a television receiver." These statements struck hard at the u-h-f defense.

Compatibility was also of acute interest to the FCC. Some of the Commissioners saw in that factor the "yes" or "no" decision. And when the RMA disclosed that their engineering department believed the simultaneous system was superior because of compatibility, as well as freedom from flicker, freedom from color fringing, freedom from color breakup, greater freedom from limitations on color reproduction and capable of providing the public with more television service at a lower price, the petition received its most staggering blow.

And while this decision sets aside the u-h-f tv standards issue, development activity will continue and effective progress will, undoubtedly, be recorded in the future. In the meanwhile, monochrome research has been placed on an accelerated schedule, with many significant developments already past the experimental stages and on the production program.

PLANS TO SKIP PHONE OPERATOR EXAMS:

There may be no more oral or written exams for those seeking Restricted Radiotelephone Operator Permits, if an FCC proposal is adopted. In the change the applicant would only have to certify that he can receive and transmit spoken messages in English; can keep a rough written log in English or in another language that can be readily translated into English, and is familiar with the provisions of the treaties, laws, rules and regulations of operation.

Simple enough!

U. S. LOOKING FOR HELP:

The latest scientific personnel bulletin issued by the Navy lists about 300 vacancies in the Office of Naval Research for radio engineers, electronic engineers, mathematicians and technical editors. The positions are open at various Naval Stations throughout the country, and there are also a few posts open in the Aleutians and Guam.

The bulletins are in file at libraries and several service offices. And we'll be very happy to show our bulletin to anyone who visits with us.

800 KC BETWEEN F-M CHANNELS:

Recent reports of interference between B-channel stations (metropolitan-rural) in such cities as Syracuse have resulted in a proposal to double the present frequency separation from 400 to 800 kc. The proximity of the channels appears also to have placed the stations too close on the dial for satisfactory tuning.

In the changes proposed by the FCC, class A and B stations would be interspersed to provide a normal minimum separation of four channels or 800 kc between class B stations in a city or immediate area. At the present time, there are 34 stations in 13 cities operating on channels 400 kc from other stations.

In the original standards, the Commission endeavored to provide from one and one-half to two times as many class B channels per city as a-m stations, with a limit of 20 class B channels for major cities like New York. Using all alternate channels, these cities required 40 of the 60 class B channels, with the remaining 20 channels used for stations in adjacent major cities.

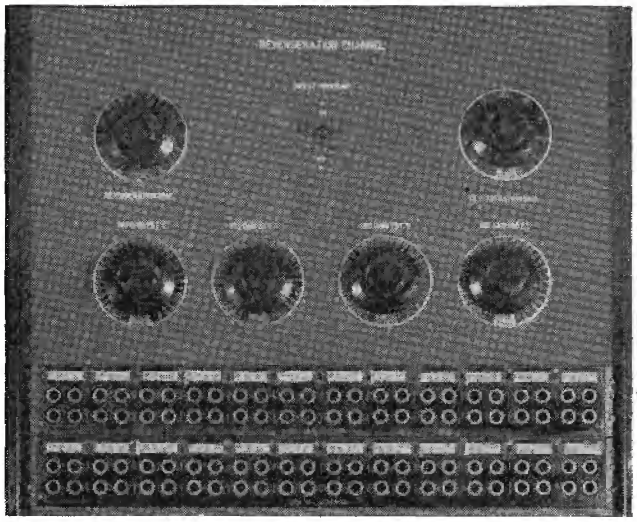
The proposed change which, by the way, will be given a hearing on May 8th and 9th in Washington, will, according to the FCC, require readjustment only of transmitters now operating and slight alterations in transmitters being built.

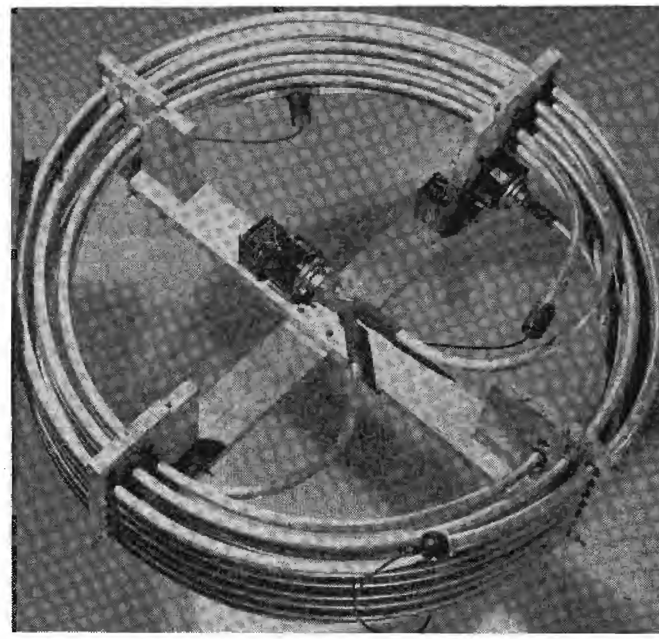
WHAT IS A SCIENTIST?:

We found quite an answer recently in an industry house organ. We learned that . . . "A thorough-going scientist is suspicious of his generalizations, his theory and laws. . . . To a scientist a theory is something to be tested. . . . He seeks not to defend his beliefs but to improve them. . . . He is, above everything else, an expert in *changing his mind*." The answer, by the way, was written by Wendell Johnson.—L. W.

(Right)
Arrangement of the tubing used in the KFI reverberation system.

(Below)
Reverberation panel with reverberation time and gain controls, and microphone gain control for 25', 50', 75' and 100'.





AUDIO PROBLEMS In A-M Broadcasting

An Analysis of Some of the Current Fidelity Problems and Solutions Found at KFI through the Use of a Controlled Reverberation Channel, Automatic Equalizing Amplifier for Transcriptions, and Intermodulation Analyzer.

by H. L. BLATTERMAN
Co-Chief Engineer
KFI, Los Angeles

ALTHOUGH SIGNIFICANT progress has been achieved in many phases of a-m broadcasting, there still are several factors which have been neglected and unfortunately dismissed by many as unworthy of further effort. This is particularly true of the fidelity problem.

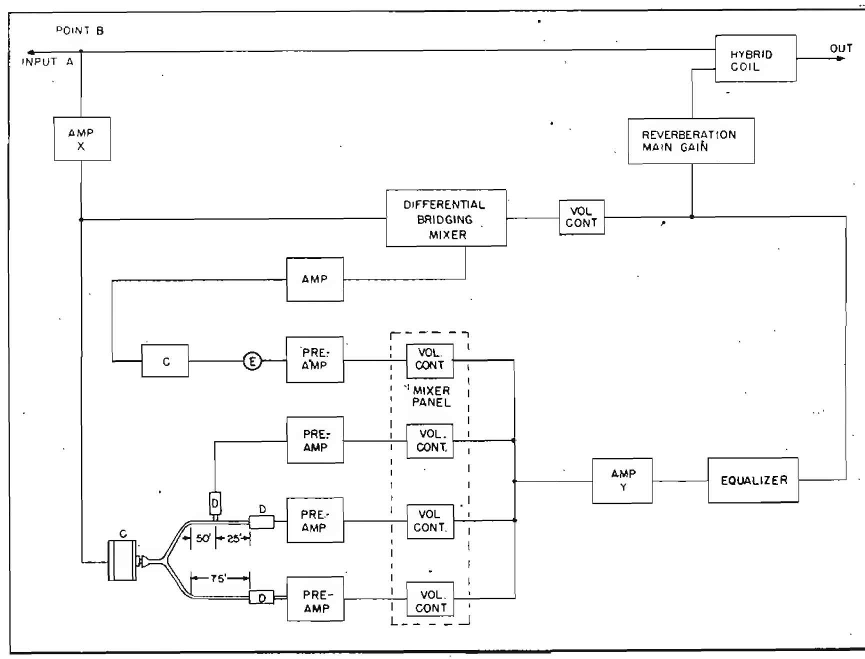
On the abstract idea of fidelity, most engineers have pretty generally accepted as their goal the transferring of music and speech, without a change, from one location to another. This is a comparatively simple process, but still difficult to attain at moderate cost. And today, we are being forced to the conclusion that in a competitive system, even this may not be enough.

The Reverberation Factor

Music and speech, in addition to having fidelity, should be easy to listen to. The human ear seems to be so constructed that, given an adequate frequency response, it is easier to convey intelligence to the brain if there is a small amount of reverberation present either in speech or music. This probably is due to the vibratory character of sound. A reenforcing of the original vibration by a reverberation acting on the ear mechanism, and prolonging the impulses, gives the brain a longer time to absorb the intelligence. Practically everyone who has had the opportunity to listen to music with and without an optimum amount of reverberation has agreed that it was more pleasant to hear; they could actually hear more with less volume on the loudspeaker, and with less effort. In addition, the music and speech had a more pleasing character.

Music is a fine art. Much of its appeal is emotional and depends on small gradations of volume and subtle tonal effects which are produced by harmonics or overtones. The magnitudes of these values are extremely small in some cases, and they are easily lost unless extreme care is taken in pickup and transmission. The fidelity of the electrical part of the system is comparatively easy to attain with currently available equipment, which provides extended frequency response from microphone to loudspeaker. However, no unanimity of opinion has been achieved when fidelity observations were limited to frequency response. The recurring arguments over so-called high fidelity and its acceptance by the public have neglected the reverberation factor, which is possibly a more important ingredient to the pleasure of the listener than an extended-

Figure 1
Reverberation channel used at KFI.



frequency response. Extended frequency response is of course desirable. However other factors such as freedom from distortion and optimum reverberation over the entire frequency range must be present before accurate evaluations of listener response to this question can be made.

It is pretty hard to evaluate the elusive reverberatory effects unless a direct comparison is available. When dealing with listener response to any sound system, it is difficult to reduce the findings to a formula unless all the variables involving that response are under control. It is only recently that any significant advances have been made in acoustic control over an extended-frequency range, and the science has certainly not been reduced to a formula.

Listener response to reverberation has been forceably and sometimes unpleasantly brought to our attention by circumstances. When the transcontinental network was first set up from New York to the coast, there was a noticeable difference in quality between the voices of our announcers and those in New York. The frequency characteristics of our equipment were better than the network, but yet, on a comparison basis, the network announcers' voices sounded rich and full toned, while the voices of our announcers were thin and washed out. Local announcements followed networks with practically no time interval, providing the listener with a direct comparison. This difference was also noted on music which was sometimes even more pronounced. It seems that there was some overall delay effect in the electrical system of the transcontinental network which sounded the same as reverberation and actually enhanced the program. As far as the listener was concerned, this was more important than the frequency response. The magnitudes of the frequency responses involved were 100 to 4,900 cycles for the networks and 50 to 8,000 cycles for the studios.

Reverberation Control

Theoretically, of course, the proper place for control of acoustics is in the theater or studio where the performance is given. In this way the performing artists, either vocal or instrumental, are helped by the reverberation of their own voice or instruments. It is easier for them to control the pitch of their voice or instrument when a considerable amount of reverberation is present. Some artists have gone to the trouble of having concealed microphones installed in the footlights and small loudspeakers placed in the wings of the theater in order to hear themselves sing or play; a simulated single reflection offering appreciable help.

Convex reflecting surfaces have been of immeasurable help in improving studio acoustics, providing an effective control of part of the frequency spectrum. However, standing waves on the bass frequencies which tend to be a function of the size of the room, rather than the shape of the walls, are still a problem.

The application of an electrical device for reverberation control has been found to be quite effective, such a system providing for: (*1*) addition of reverberation; (*2*) control of reverberation in minute degrees; (*3*) control of reverberation in different points in the frequency spectrum.

Most networks and large broadcast stations use an electrical system that provides some of the foregoing features. For instance, the use of a small live room connected to the electrical part of the system through pipes, microphones and loudspeakers is generally used. In general, this is susceptible to resonant peaks which are hard

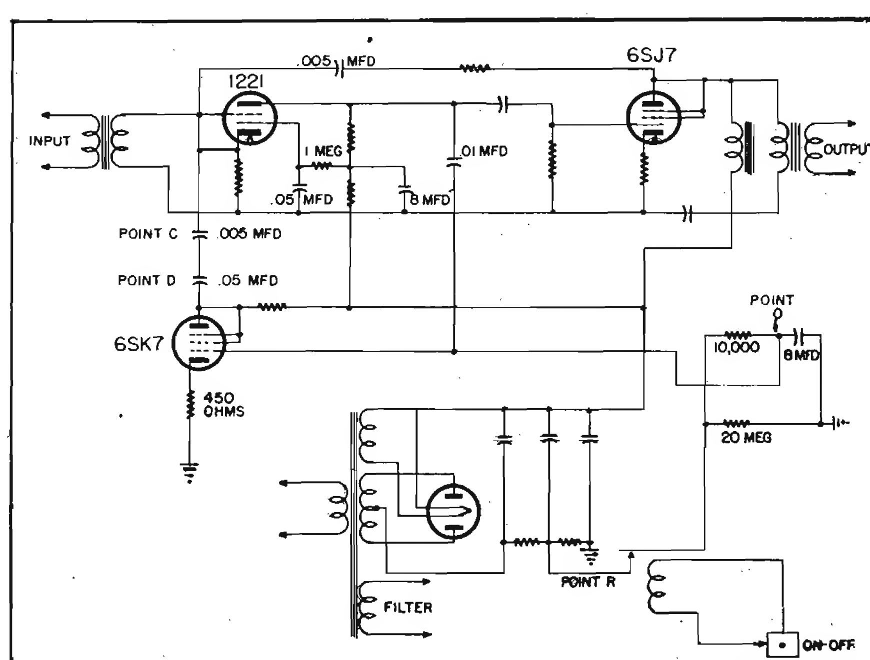


Figure 2
Automatic equalizing playback amplifier, featuring a two-stage preamplifier with equalizing feedback.

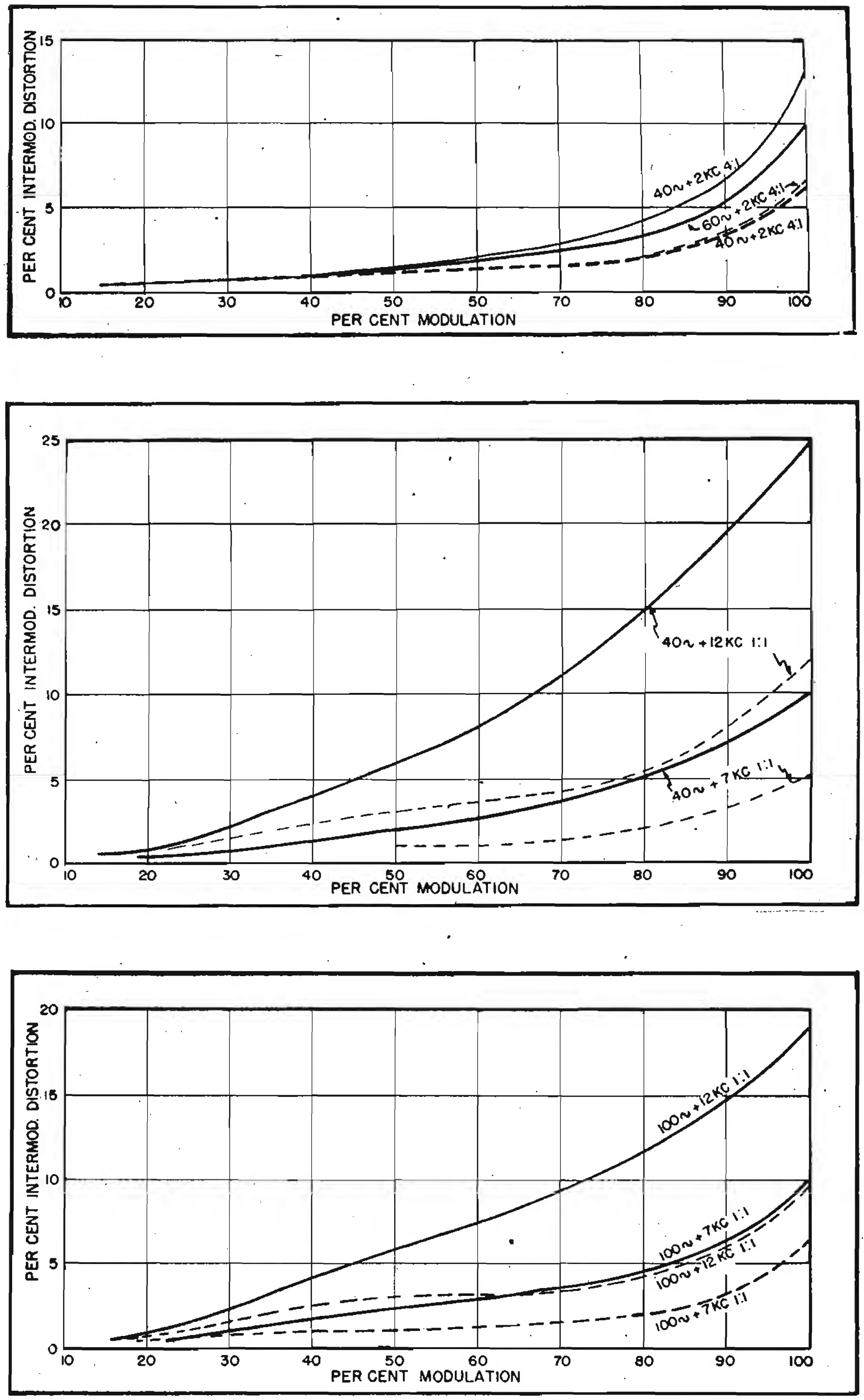


Figure 3

Sample of intermodulation curves of 50-kw transmitter showing reduction in intermodulation distortion effected through use of intermodulation analyzer. The solid line shows the result *before* tuning of final grid circuit and the dashed line shows the *after* result.

to control. A further development of this procedure has been underway at the RCA Laboratories at Princeton, New Jersey, under the direction of Dr. H. F. Olson.

As a result of observations of this system a project[1] to develop a similar device was initiated in 1946. The developed system consisted essentially of four sections of coiled pipe through which sound was transmitted, delayed, fed back and allowed to travel and decay, then mixed with the original sound in order to produce synthetic reverberation.

As this unit was developed and used on actual programs, it was found that the frequency response of the speaker, pipe and microphone unit had to be perfectly flat. A difference of a few db at any one frequency produced a tendency to oscillate and destroy its usefulness. After the frequency response had been made flat, it had to be made controllable both as to the amount of reverberation used, and as to the time period of said reverberation.

Reverberation System Operation

In Figure 1 appears a block diagram of the reverberation channel developed at KFI. Input *A* is bridged at *B* by an amplifier *X*, whose output is connected to *C*, a modified loudspeaker unit.[2] The speaker is connected by a special acoustic device and *Y* connector to 25′, 50′ and 75′ sections of 1″ coiled aluminum pipe. The signal passes through these sections of pipe and is delayed according to the length of pipe, then equalized and fed through hybrid coil to output.

A branch circuit is taken from the output of amplifier *X* and fed through a differential bridge mixer to the speaker, *C*, connected to the 100′ pipe. The output of this is mixed through conventional methods with the outputs of the 25′, 50′, 75′ sections. The volume from each of these acoustic paths can thus be balanced accurately. In order to get true reverberatory effects, it is necessary to return a portion of the output of amplifier *Y* and send it through the 100′ section of pipe, again and again.

This procedure simulates the reverberation effects of any given studio. In addition, the time period of reverberation is controllable with the mixing panel and the amount of reverberation main gain. It was found that extreme care was necessary in equalizing electrical circuits and in coupling speakers and microphones to pipes.

The results, however, seem to justify the somewhat elaborate circuits. We are in the process of learning how to use the device, and in general, we are guided by the effects wanted by our staff musical director and production men. It is remarkable how a small amount of reverberation used in the right spots enhances the music of an orchestra or vocalist.

We intend to incorporate a control so that reverberation can be peaked at certain frequencies. This will allow the operator to compensate for de-

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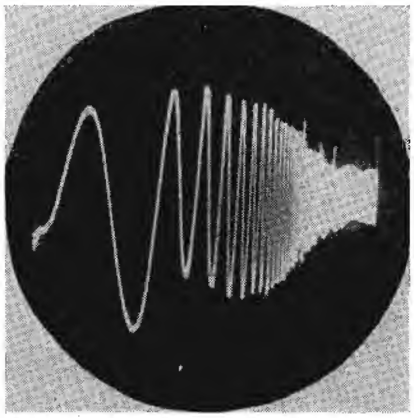
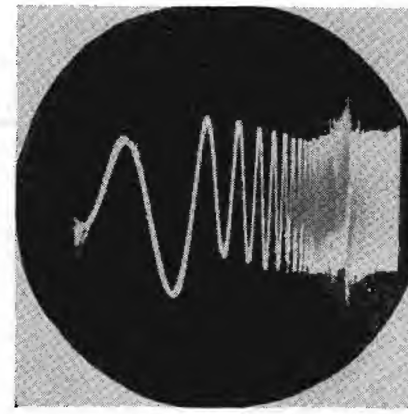
[1]Development by Wayne Johnson, KFI Research and Development Department, which is under the director of George Curran.

[2]W.E. 555.



Figures 4*a* (left) and *b* (right)

At *a* appears an actual photograph of a normal frequency response at inside diameter of 8″ of a 136-line transcription, with *no* equalizing amplifier in circuit. In *b* appears an actual photograph of the frequency response of the same type record with, however, the equalizing amplifier in the circuit.



ficiencies in reverberation which occur in the studio itself.

Delayed Transcription Fidelity Problems

Another fidelity problem has appeared in the delayed transcriptions used to rebroadcast coastal shows, which cannot be presented at originating time at either coast because of the time differentials. For instance, the half-hour Jack Benny show, which originates at 4:00 P.M. on the west coast, is recorded and rebroadcast locally at 9:30 P.M. P.S.T. Thus advertising agency, performers and at-home listeners form a critical and highly articulate audience for our transcription efforts.

The fidelity problem involved the inevitable loss of high frequencies which occurs at the inside start of every transcription. It was particularly noticeable on a half-hour show when switching instantaneously from the outside of one record to the inside of another. Various methods of equalizing the recordings were tried and discarded. Super-imposing diameter equalization on top of the standard NAB preemphasis curve proved impractical because the high frequency peaks overloaded badly and caused a high degree of intermodulation distortion. The actual readings taken on measuring equipment ran as high as 60% intermodulation.

The obvious alternative was to incorporate diameter equalization in the playback instead of the recording. It was also impractical to use any mechanical switch operated by a delicately balanced playback mechanism. Switches are step-by-step affairs and tend to get noisy, especially in low-level circuits, and are thus quite objectionable.

We found that the problem could be solved electrically with a capacitor-resistor combination, by charging it and allowing it to leak off at a rate equal to the rate at which the high frequencies build up as the playback needle moves away from the inside diameter of the recording.

Circuit Operation

The capacitor-resistor combination is placed in a circuit which controls a frequency conscious feedback loop in the pre-amplifier. In actual practice, this changes the playback frequency characteristic of the amplifier from deemphasis to esentially flat at the beginning of the record. This compensates for the loss of the highs at the start of the playback. The needle velocity is low at this diameter, so that needle scratch is essentially the same on both inside and outside diameter of the record.

It will be found by test that most of the high frequencies are lost in the first five minutes of playback and the loss changes logarithmically as the needle travels away from center. Fortunately this is the way a capacitor-resistor combination discharges, and therefore, makes a perfect compensating device.

The circuit, providing an automatic equalizing amplifier, consists of a conventional two-stage preamplifier with equalizing feedback.

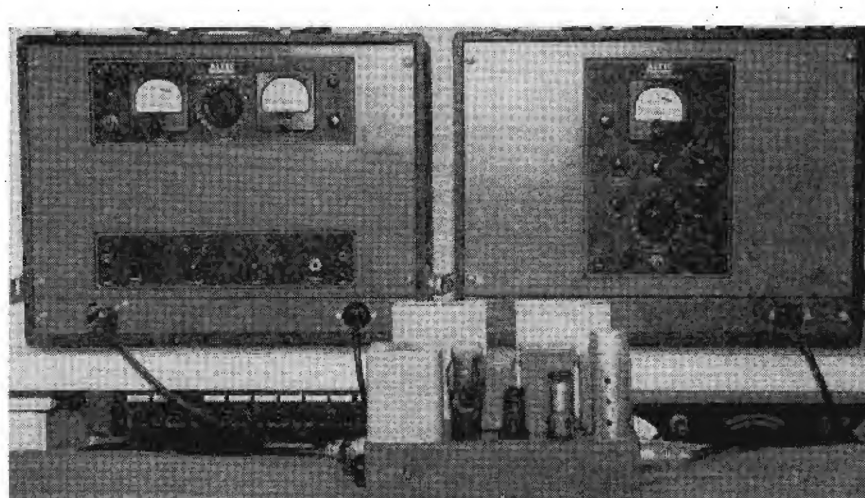
When the amplifier is placed in operation and turntable switch turned off, relay *R* is closed, allowing capacitor *C* to charge with voltage from tap on *B* power supply. The voltage at point *O* is applied to the grid of the 6SK7, biasing the tube to cutoff and nullifying the effects of capacitors *B*, *C* and *D* on the frequency characteristic of the first stage. Capacitors *B*, *C* and *D* form a feedback path which is adjusted frequency-wise by capacitor *C* to the deemphasis curve, but only when the 6SK7 tube is not biased to cutoff.

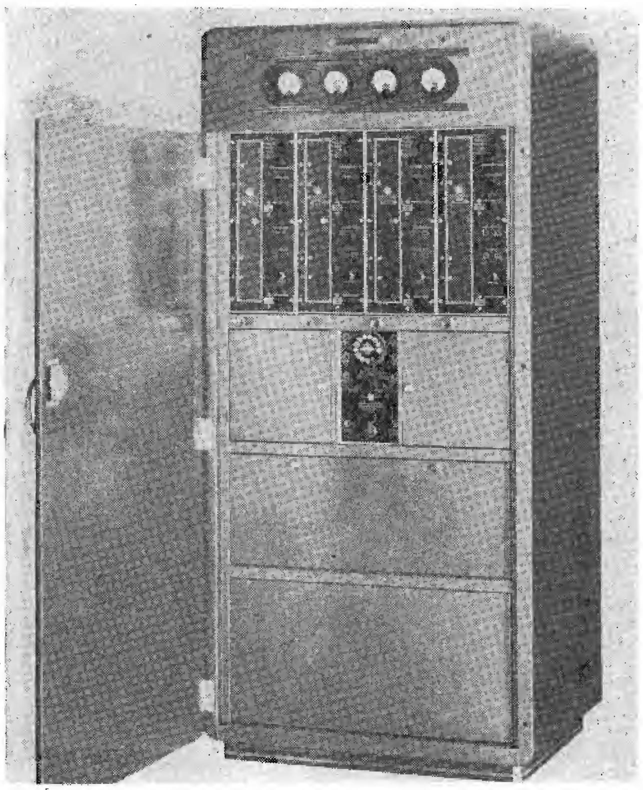
When the relay *R* is operated (by starting switch on the turntable) the charging voltage is lifted from point *O* and capacitor immediately begins discharging through 10,000-ohm and 20-megohm resistors. This slowly changes the bias on 6SK7, thus closing feedback path formed by capacitors *C*, *D* and *B*, and slowly drops the high-frequency characteristic of the amplifier down to the deemphasis playback curve. By the time this has taken place, the playback has moved to a position on the record which calls for

(*Continued on page* 50)

Figure 5

Equalizing amplifier setup with a-f signal generator and intermodulation analyzer test equipment.





Ground-Air

Figure 1

Front view of the air-ground transmitter with four r-f channel units mounted in position. Cabinet is 72" high, 32" wide and 26" deep.

AIRLINE COMMUNICATIONS SYSTEMS, which began to function on a reasonably advanced scale between 1925 and 1930, provided for, principally, the application of airborne radio equipment to post the pilot on weather, field conditions, etc. The pilot likewise conveyed similar information to the ground, including position reports, if required.

The transmitters on the aircraft were of the c-w type and were of relatively low power, 25 watts or less. The ground stations were similar to the aircraft installations but of slightly increased power. Considering the state of the radio and the aircraft art, this equipment served its purpose very well. Many of the airlines covered long-distances by a series of short hops. These short hops with small flying equipment made low powers satisfactory. The development of larger aircraft permitted longer distances between stops and provided space for more powerful radio equipment on the airplane. The longer distances between stops, and the need for increased reliability in communications due to the dependence of operations on this factor, demanded greater power in ground-station communications installations.

The trend towards greater distances and higher power equipment continued until about 1938 when powers of 5-kw were in use on the ground and 100 watts in the air. The flights were between large centers where the traffic density was high. The small waystations, where traffic density was low, were bypassed.

Shortly after 1938, the airlines began to think seriously of the traffic possibilities of the smaller hitherto bypassed cities and began to plan accordingly. In analyzing the communications aspects of the small city program, we found that new types of ground-communications equipment would be required.

For instance, equipment could emit less power. For the most part, the smaller stations were situated between the large stations with an obvious decrease in radio transmission distances. The power of one-fifth to one-sixth the larger stations was determined to be most desirable from an operation, cost, and size of equipment standpoint. Placing the larger equipment at 2,500 to 3,000 watts output, the smaller intermediate-power transmitter could then be approximately 400 to 500 watts.

With night and day frequencies, and quadrature traffic distribution in use, it was felt that the equipment should have more than one channel and preferably four channels, with at least two of these channels operating simultaneously on radiotelephone.

To accommodate the widely separated frequency bands assigned to aeronautical services, 200-400 kc, 2-12 mc, and 108-132 mc, it became quite apparent that three distinct types of r-f transmitting channels would have to be provided, operating at fixed frequencies within these ranges. The use of a common power supply and modulator for all r-f channels was considered feasible.

(Provision for the four transmitting channels in three frequency ranges, provided a solution for the problems which confronted the industry in changing the bulk of radio communications from the 2-12 range to 108-132 mc.

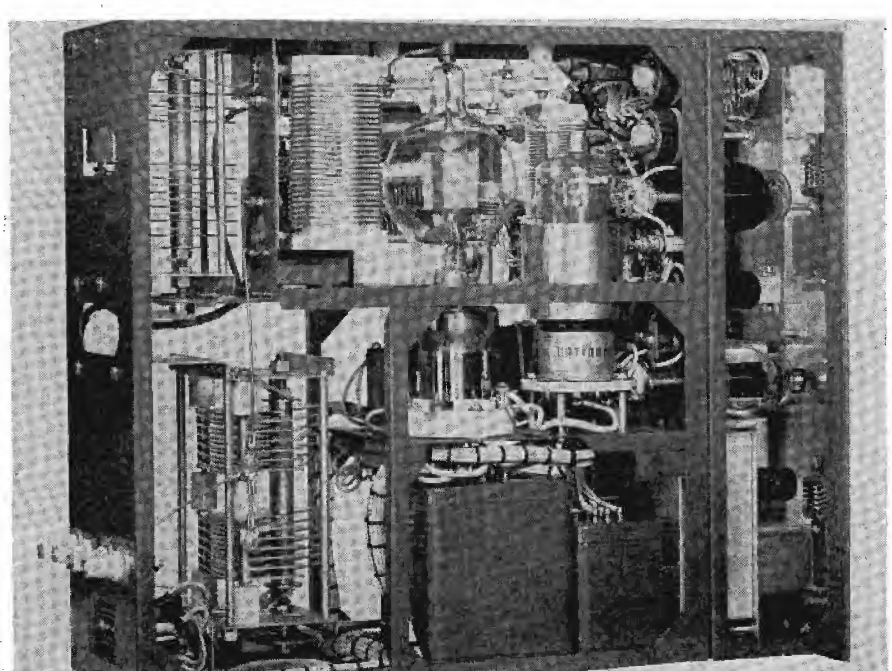


Figure 2

The 2-20-mc r-f unit removed from its cabinet.

COMMUNICATIONS UNIT

Medium-Powered Transmitter, Developed for Commercial Airline Service, Features Three Types of R-F Channels: 125 to 525 kc, 2 to 20 mc, and 100 to 160 mc. System Also Applicable to Police, Navigation and Other Point-to-Point Services.

by S. A. MEACHAM

Wilcox Electric Co., Inc.

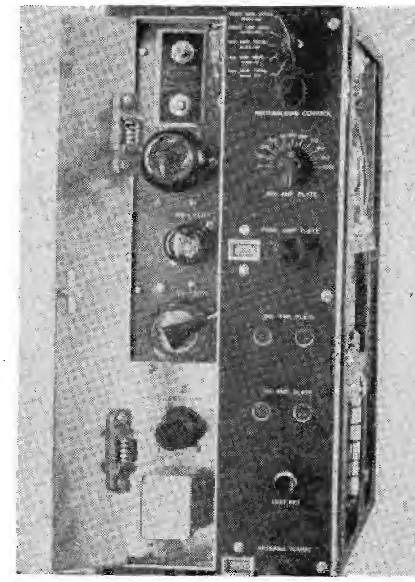


Figure 3
The 2-20-mc r-f unit. At the left of the cabinet are the bias isolator circuit and keying tubes.

This change, it was realized, would occupy a period of years, during which communications would necessarily be carried on in *both* the foregoing frequency ranges, a feature practical only with a transmitter having separate r-f channels designed for these frequencies.)

In many foreign applications, and even in certain domestic operations, the inclusion of an r-f channel covering the 200-400 kc band could provide for the use of the transmitter as a non-directional radio beacon as an aid to navigation. Actually, the frequency range of the channel was extended from 125 to 525 kc.

As a result of these analyses and tests with several models, a medium-powered ground-station transmitter[1] was developed.

Three types of r-f channels have been provided; 125 to 525 kc, 2 to 20 mc, and 100 to 160 mc. The cabinet has been designed to accommodate four of these r-f channels, in any combination that may be desired.

The medium frequency unit is complete from the crystal oscillator through to the final amplifier and antenna coupling circuits. All power supplies, with the exception of the filament transformers, are external to the r-f units. All coils to cover the required frequency range, with the exception of the final amplifier plate coil, and the driver-amplifier plate coil, are self-contained and require only band switching to select the desired frequency range.

A high velocity air stream from two blowers in the base of the cabinet is directed by internal ducts to each of the four r-f channels, as well as to the rectifier and modulator components. Air air-operated switch, connected in the transmitter overall interlock circudit, is situated in each of the two air streams. In the event of the failure of either blower, the transmitter is automatically disabled, protect-

[1] 99A.

Figure 4
Internal view of the 100-160-mc r-f unit.

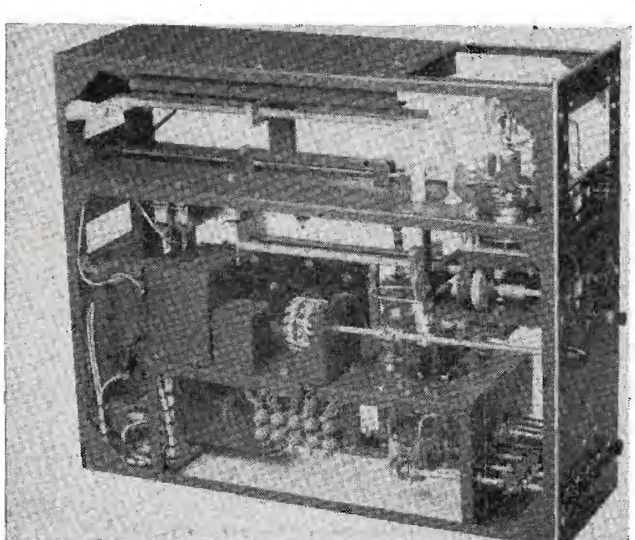
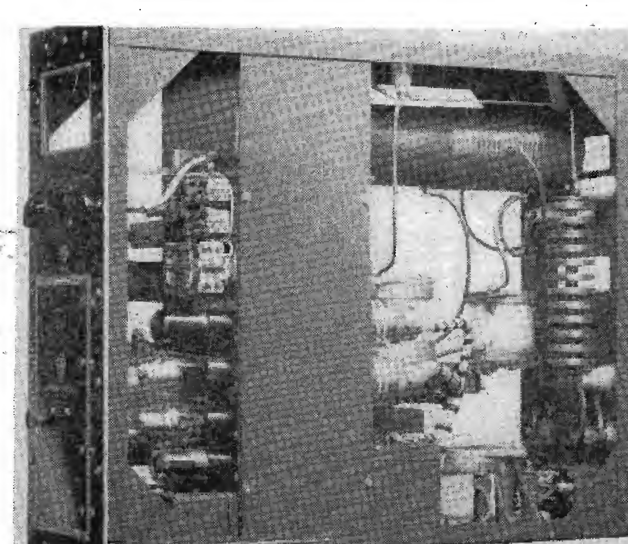


Figure 5
A view of the 125- to 525-kc r-f channel unit with the rear panel removed.

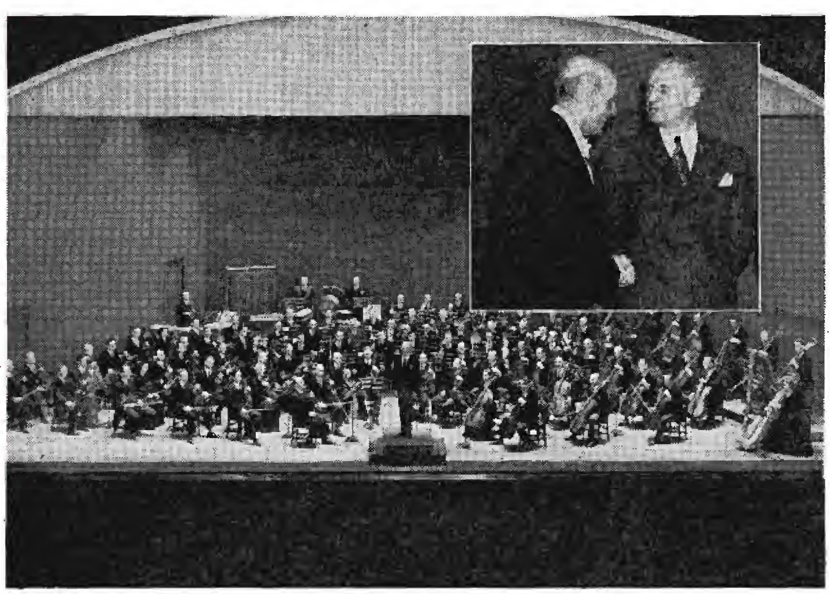


SQUARE-LOOP FM ANTENNA MAKES WORLD DEBUT!

WTCN-FM, Minneapolis, goes on the air with most efficient FM Antenna installed anywhere . . . boosts 3kw transmitter to 25kw . . . with coverage of 30,000 square miles

FEDERAL's 8-Element Square-Loop Antenna made radio history with the opening of the Twin Cities FM station, WTCN — the first super-directive antenna of its type and power gain to be installed anywhere. It gives the 3kw Federal transmitter an effective radiated power of 25kw — providing excellent reception over an area of approximately 30,000 square miles. This makes WTCN the world's *most efficient* FM station—and, with an FCC permit for an output of 400kw, it will eventually be one of the country's *most powerful* stations, too. With Federal's high-gain antenna, this maximum rating of 400kw can be achieved with the installation of only a 50kw transmitter!

WTCN is among the FM stations with permits for the most powerful ratings in the country. Others are KWK, St. Louis, with 369kw — and WTMJ, Milwaukee, with 349kw. These three stations have *all* selected *FM by Federal!* And Federal can equip your new FM station, too — from microphone to antenna. Write today for complete information. Dept. B310.



Station WTCN was officially opened by a gala inaugural program featuring the Minneapolis Symphony Orchestra, Dimitri Mitropoulos conducting. With FM by Federal, listeners at home were enabled to hear this famous orchestra with the same brilliance and tonal color as the studio audience. Insert shows Mr. Mitropoulos and Governor Luther W. Youngdahl of Minnesota, at opening of ceremonies.

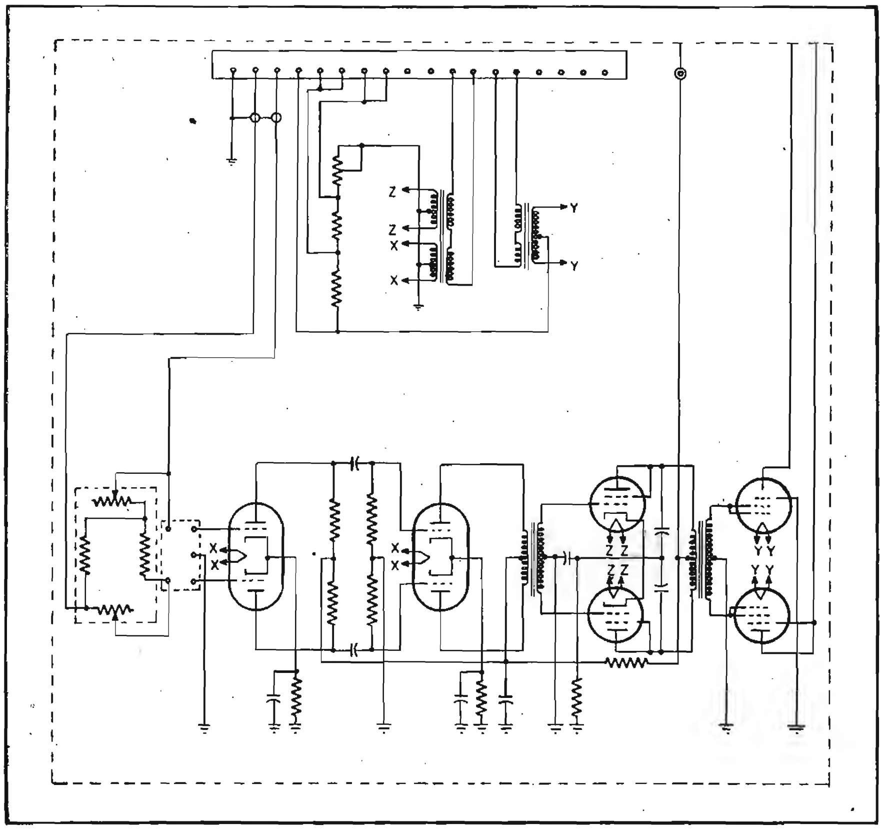
"Wonderful! Magnificent! A terrific step of progress." This was the comment of the famed conductor, Dimitri Mitropoulos, when he heard his own orchestra over an FM receiver, during an on-the-air rehearsal.

and Radio Corporation

Newark 1, New Jersey

AN IT&T ASSOCIATE

FEDERAL TELEPHONE & RADIO FTR



Modulator unit, one of four, used in the commercial airline transmitter.

ing the component parts from excessive heating.

Medium H-F Channel Features

Since a detailed description of each of the three types of r-f channels would be too lengthy, the medium h-f range channel (2 to 20 mc) has been selected as a representative unit for discussion.

The unit features a crystal-controlled shielded oscillator permitting continuous operation of the oscillator circuit. Greater stability and a less active oscillator circuit is accomplished in this manner, thus offering a considerably reduced strain on the quartz plate.

The oscillator is followed by a first amplifier buffer, a second amplifier doubler, and third amplifier or doubler and the final amplifier.

With a rated power output of 400 watts, the actual power output is usually closer to 500 watts under normal load and line voltage conditions. The amplifier-doubler stages afford a means of deriving the output frequency with sufficient power to drive the final amplifier. Adequate drive of the final amplifier at all frequencies is necessary to provide high efficiency in the final amplifier and to provide equal output at any point in the operating band.

The circuit of the radio frequency unit is straightforward with no radical features. Compactness has been obtained by considering each part carefully before placing it in the design. A bias isolation circuit has been provided for the final amplifier. Bias isolators in power this low are usually not employed. However, by the use of this feature, the size of the bias supply is greatly reduced. The isolator provides grid bias for the tube at all times during a static condition of the final amplifier. When the final amplifier is being driven, the bias supply no longer furnishes bias voltage. The isolator tube employed becomes a grid leak, thus providing a self-bias during dynamic or driven conditions. A protective relay system is employed which removes all damaging voltages from the circuits of the transmitter when the bias voltage supply fails.

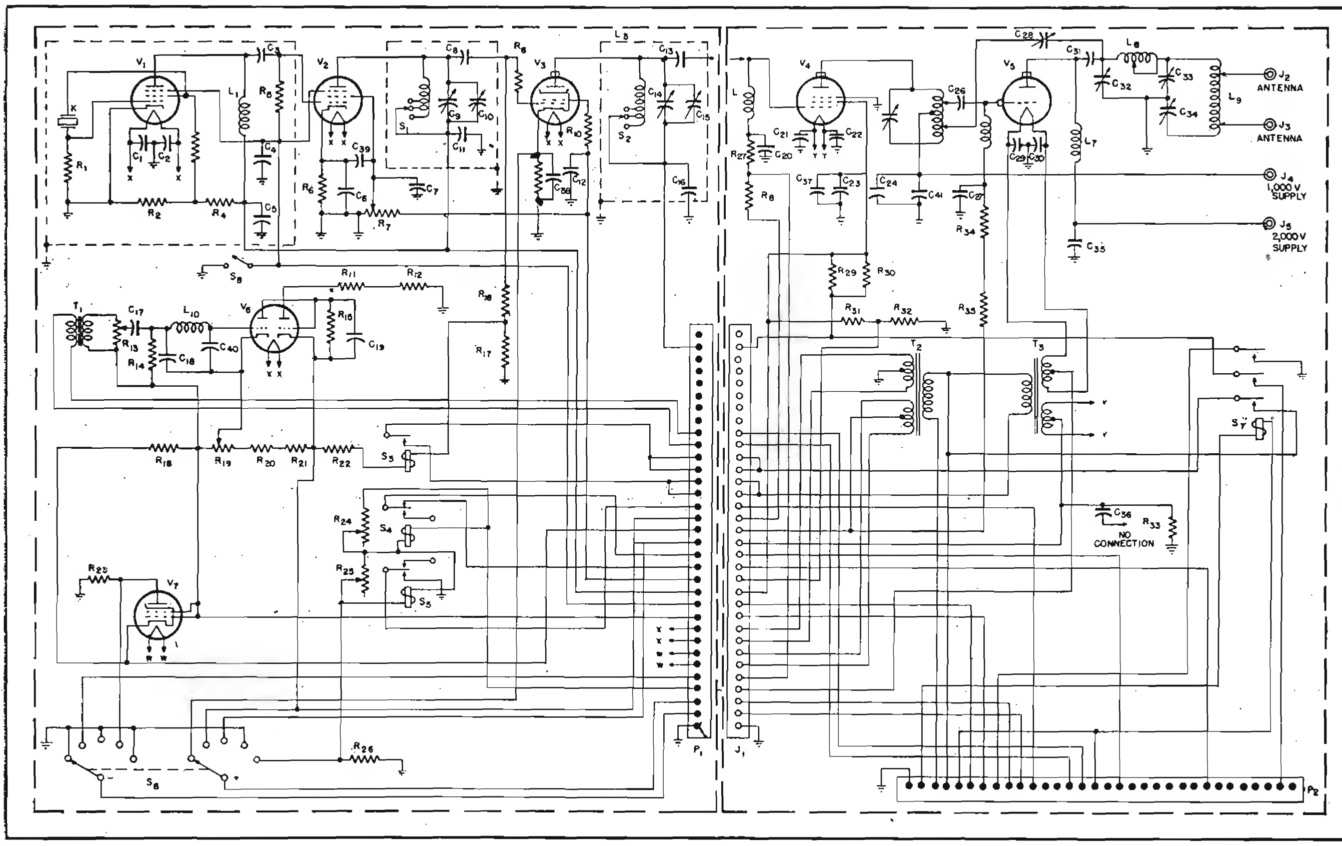
An underload-overload relay system is also employed. The overload relay which operates from the final amplifier plate current is adjusted by means of a parallel shunting resistance. The relay is adjusted to operate at a predetermined point just above the normal operating final amplifier total current. An increase in current of the final amplifier will cause the relay to operate. Upon operation the relay contacts open the primary contactor of the high voltage transformers. This overload circuit cycles as long as the overload exists. On exceedingly heavy overloads the cycling continues several times until the fuse of the overloaded circuit blows out. The underload circuit is adjusted to operate at a current point slightly below normal operating current for the final amplifier. The contacts of the relay controlled in this circuit are used to switch the filaments of the modulator to an operating condition. By means of this circuit, the modulator is turned on only if the

(*Continued on page 52*)

At left, below, list of parts for the v-h-f unit. At right, below, list of parts for the medium frequency unit.

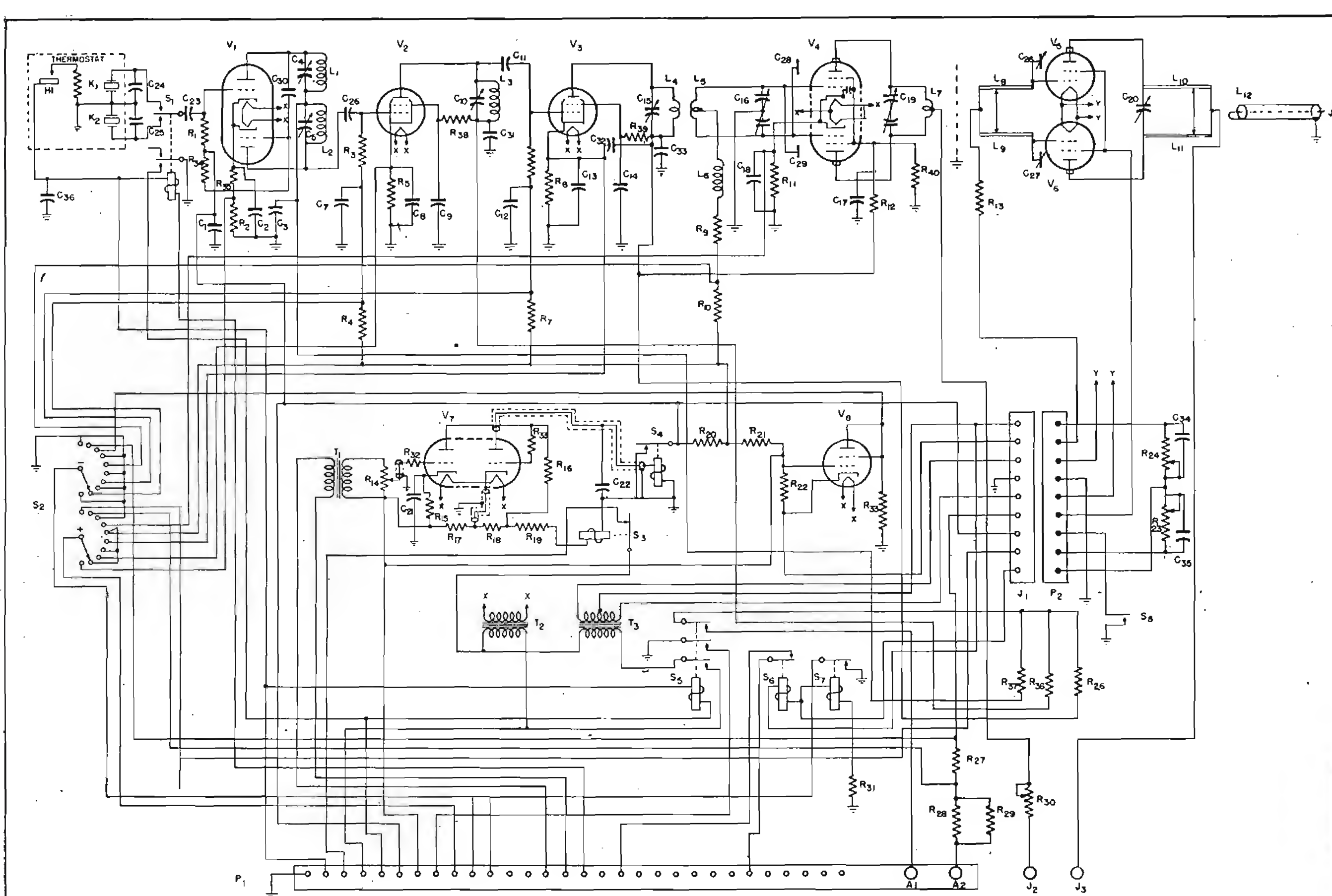
C1	.002 MFD 500 V.	R1	47,000 OHMS 1 W.	L1	OSC. PLATE INDUCTOR
C2	.002 MFD 500 V.	R2	112.8 OHMS 1 W.	L2	1ST AMP. GRID HARMONIC TANK IND.
C3	.002 MFD 500 V.	R3	47,000 OHMS 1 W.	L3	1ST AMP. PLATE INDUCTOR
C4	50 MMFD VARIABLE	R4	112.8 OHMS 1 W.	L4	2ND AMP. PLATE INDUCTOR
C5	25 MMFD VARIABLE	R5	4.3 OHMS 1 W.	L5	3RD AMP. GRID INDUCTOR
C6	500 MMFD 500 V.	R6	47,000 OHMS 1 W.	L6	3RD AMP. GRID CHOKE
C7	500 MMFD 500 V.	R7	112.8 OHMS 1 W.	L7	3RD AMP. PLATE INDUCTOR
C8	500 MMFD 500 V.	R8	4.3 OHMS 1 W.	L8	FINAL AMP. GRID INDUCTOR
C9	500 MMFD 500 V.	R9	2,000 OHMS 1 W.	L9	FINAL AMP. GRID INDUCTOR
C10	25 MMFD VARIABLE	R10	112.8 OHMS 1 W.	L10	FINAL AMP. PLATE INDUCTOR
C11	500 MMFD 500 V.	R11	4.3 OHMS 1 W.	L11	FINAL AMP. PLATE INDUCTOR
C12	500 MMFD 500 V.	R12	5,000 OHMS 10 W.	L12	ANTENNA COUPLING LINK
C13	500 MMFD 500 V.	R13	5,000 OHMS 20 W.		
C14	500 MMFD 500 V.	R14	100,000 OHMS POT.		
C15	25 MMFD VARIABLE	R15	3,000 OHMS 1 W.		
C16	25-25 MMFD VARIABLE	R16	500,000 OHMS 1 W.	V1	OSC. 6J6
C17	500 MMFD 500 V.	R17	800 OHMS 10 W.	V2	1ST AMPLIFIER 6AQ5
C18	500 MMFD 500 V.	R18	2,500 OHMS 10 W.	V3	2ND AMPLIFIER 6AQ5
C19	35-35 MMFD VARIABLE	R19	3,000 OHMS 10 W.	V4	3RD AMPLIFIER 829-B
C20	SPECIAL VARIABLE	R20	1,000 OHMS 10 W.	V5	FINAL AMPLIFIER 4-125A
C21	500 MMFD 500 V.	R21	10,000 OHMS 10 W.	V6	FINAL AMPLIFIER 4-125A
C22	1 MFD 200 V.	R22	100,000 OHMS 1 W.	V7	ELECTRONIC KEYER 6SN7GT
C23	10 MMFD 300 V.	R23	4.3 OHMS 1 W.	V8	BIAS ISOLATOR 6V6GT
C24	15 MMFD 300 V.	R24	25 OHMS 25 W. POT.		
C25	15 MMFD 300 V.	R25	25 OHMS 25 W. POT.		
C31	510 MMFD 500 V.	R26	5,000 OHMS 50 W.		
C32	510 MMFD 500 V.	R27	4.3 OHMS 1 W.	S1	CRYSTAL SELECTION RELAY
C33	510 MMFD 500 V.	R28	10,000 OHMS 50 W.	S2	METER SELECTOR SWITCH
C34	500 MMFD 500 V.	R29	10,000 OHMS 50 W.	S3	BIAS PROTECTION RELAY
C35	500 MMFD 500 V.	R30	4,000 OHMS 200 W.	S4	KEYING RELAY
C36	.002 MFD 500 V.	R31	2.0 OHMS 1 W.	S5	CHANNEL CONTROL RELAY
		R32	250,000 OHMS 1 W.	S6	OVERLOAD RELAY
		R33	100,000 OHMS 1 W.	S7	UNDERLOAD RELAY
		R34	47,000 OHMS 1 W.	S8	TEST KEY
		R35	510 OHMS 1 W.		
		R36	10,000 OHMS 20 W.		
		R37	20,000 OHMS 20 W.		
		R38	50,000 OHMS 1 W.		
		R39	25,000 OHMS 1 W.		
		R40	15,000 OHMS 20 W.		

C1	.01 MFD 300V.	R1	100,000 OHM 1 W.	K	CRYSTAL
C2	.01 MFD 300V.	R2	24,000 OHM 1 W.	L1	OSC. PL. R-F CHOKE
C3	.002 MFD 500V.	R3	240,000 OHM 1 W.	L2	1ST. AMP. PL. TANK INDUCTOR
C4	.01 MFD 300V.	R4	60,000 OHM 1 W.	L3	2ND AMP. PL. TANK INDUCTOR
C5	.002 MFD 500V.	R5	51,000 OHM 1 W.	L4	3RD AMP. GRID R-F CHOKE
C6	.01 MFD 300V.	R6	470 OHM 1 W.	L5	3RD AMP. PL. TANK INDUCTOR
C7	.01 MFD 300V.	R7	50,000 OHM 4 W.	L6	FINAL AMP. GRID R-F CHOKE
C8	.002 MFD 1,000V.	R8	51 OHM 1 W.	L7	FINAL AMP. PL. R-F CHOKE
C9	75 MMFD	R9	4.3 OHM 1 W.	L8	FINAL AMP. PL. TANK INDUCTOR
C10	75 MMFD	R10	50 OHM 1 W.	L9	ANTENNA LOADING INDUCTOR
C11	.002 MFD 1,000V.	R11	10,000 OHM 1 W.	L10	ELECTRONIC KEYER GRID CHOKE
C12	.01 MFD 300V.	R12	100,000 OHM 1 W.		
C13	.002 MFD 1,000V.	R13	100,000 OHM 1 W.		
C14	75 MMFD	R14	240,000 OHM 1 W.	V1	OSC. 6AC7/1852
C15	75 MMFD	R15	240,000 OHM 1 W.	V2	1ST. AMP. 6AC7/1852
C16	.002 MFD 1,000V.	R16	15,000 OHM 1 W.	V3	2ND. AMP. 807
C17	.1 MFD 600V.	R17	1,000 OHM 2 W.	V4	3RD. AMP. 813
C18	.01 MFD 300V.	R18	100,000 OHM 1 W.	V5	FINAL AMP. 250TL
C19	.01 MFD 300V.	R19	500 OHM 10 W.	V6	KEY. CONT. 6SN7GT
C20	.002 MFD 500V.	R20	510 OHM 1 W.	V7	BIAS. ISOL. 6L6G
C21	.002 MFD 500V.	R21	2,000 OHM 10 W.		
C22	.002 MFD 500V.	R22	1,750 OHM 10 W.		
C23	.002 MFD 500V.	R23	4.3 OHM 1 W.		
C24	.001 MFD 2,500V.	R24	25 OHM 25 W.		
C25	150 MMFD 2,000V.	R25	25 OHM 25 W.		
C26	.001 MFD 2,500V.	R26	2 OHM 1 W.		
C27	.001 MFD 2,500V.	R27	25,000 OHM 10 W.		
C28	2.9-12 MMFD 9,000V.	R28	112.8 OHM 1 W.		
C29	.001 MFD 2,500V.	R29	10,000 OHM 20 W.		
C30	.001 MFD 2,500V.	R30	10,000 OHM 20 W.		
C31	.002 MFD 12,500V.	R31	5,000 OHM 20 W.		
C32	180 MMFD 6,750V.	R32	5,000 OHM 20 W.		
C33	350 MMFD 2,250V.	R33	4.3 OHM 1 W.		
C34	350 MMFD 2,250V.	R34	2,500 OHM 20 W.		
C35	.002 MFD 6,000V.	R35	2,500 OHM 20 W.		
C36	.002 MFD 500V.				
C37	8 MFD 450V.				
C38	.01 MFD 300V.				
C39	.01 MFD 300V.				
C40	.002 MFD 500V.				
C41	.001 MFD 2,500V.				



The medium frequency unit of the airline transmitter.

Circuit of the v-h-f unit of the ground-air transmitter.



Vertically Polarized Nondirectional BROADBAND RADIATOR

Fixed Station Antenna Designed for Railroad and Other Services Operating in the 152-162 mc Band.

by J. P. SHANKLIN

Project Engineer
Bendix Radio, Division of Bendix Aviation Corp.

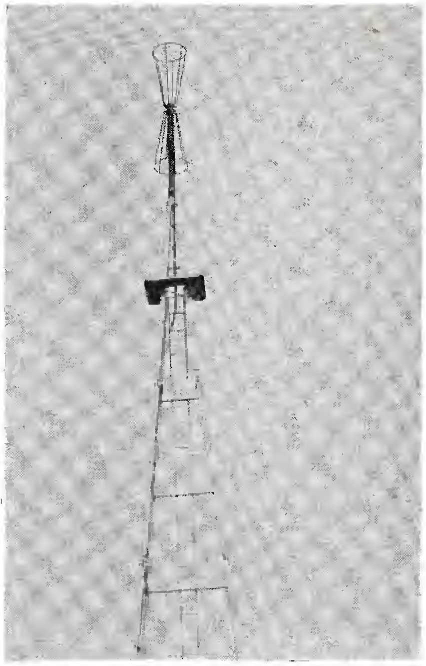


Figure 1 (left, top)
Fixed station antenna installation atop office building of the Frisco Lines R.R. at Springfield, Missouri.

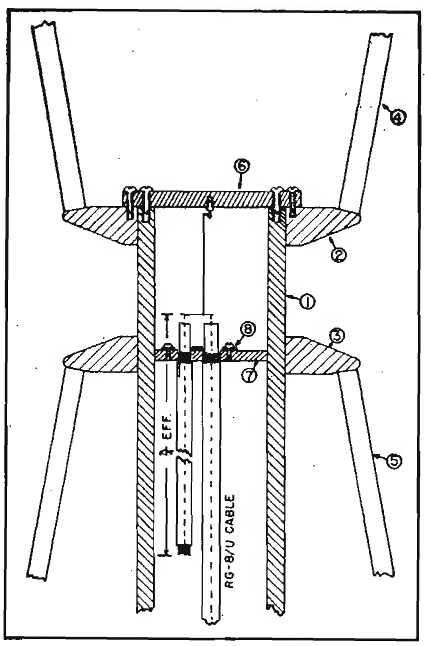


Figure 3 (left)
Method of feeding the biconical antenna. At *1*, phenolic supporting tube; *2* and *3*, clamps on to which are welded rods *4* and *5*; *6*, metal end plate electrically connected to upper cone by screws; and *7*, internal metal disc connected electrically to clamp *3*. The outer braid of the coaxial feed cable is clamped to *7* by plate *8* and screws.

THE NEED FOR COMPACT-type antennas for v-h-f fixed station operation has prompted the development of several interesting and effective types for a variety of applications. In Figure 1 appears one such type,[1] a vertically polarized antenna composed of two truncated conical structures, mounted coaxially with their smaller end together and fed at this point, each cone being $\lambda/2$ long at 157 mc.

The antenna would at first appear to be equivalent to stacked cophased $\lambda/2$ dipoles and so radiate a similar vertical pattern. However, due to the end loading caused by the rings in the ends of the cones and also the large cross sectional area of the cones, the current distribution is such that the pattern is sharpened and becomes very similar to the theoretical pattern of stacked cophased $5/8\lambda$ antennas. This last is the highest gain pattern possible from two radiating elements mounted colinearly.

In Figure 2 appears an experimentally obtained vertical radiation pat-

(*Continued on page* 51)

[1]MS-110A Biconical Antenna.

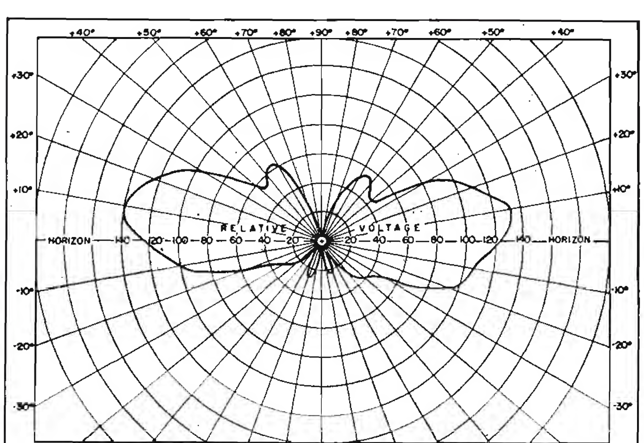
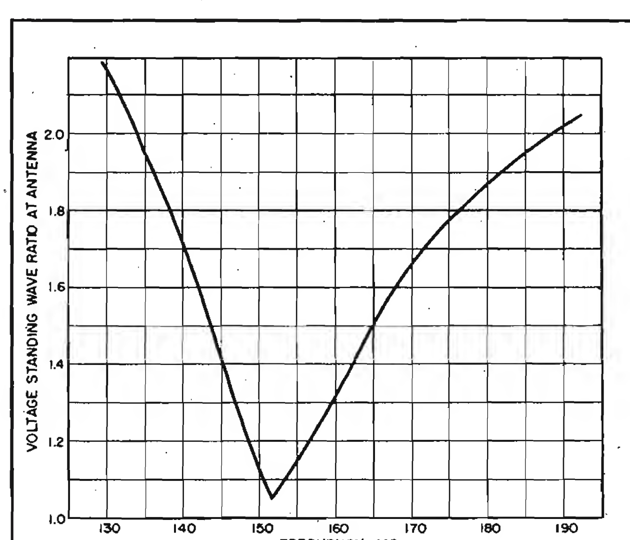


Figure 2 (above)
Experimentally obtained vertical radiation pattern of antenna.

Figure 4
A s-w-r versus frequency plot for the biconical antenna.



PUTTING A NEW F-M STATION On The Air

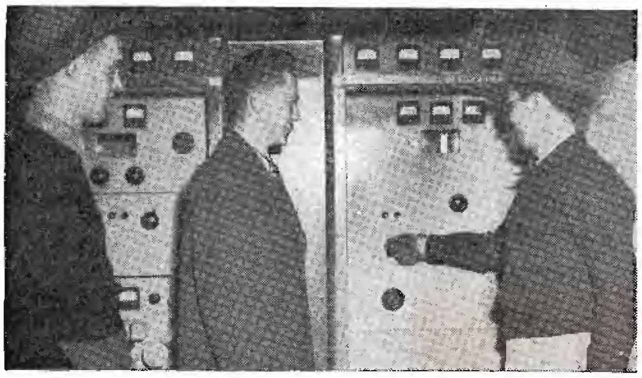


Figure 1
George W. Yazell at the controls of the WCFC f-m transmitter. At extreme left, Wally Warren, station engineer; center, Sid Doherty, announcer.

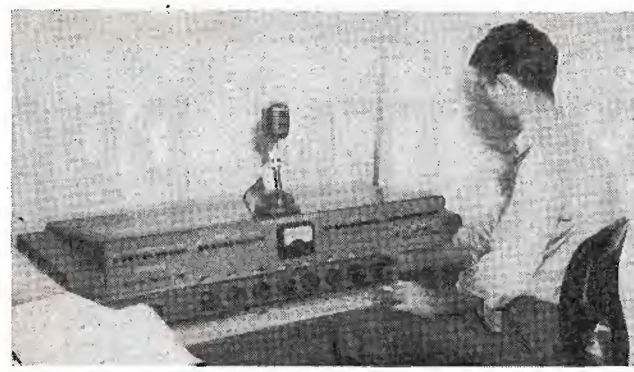


Figure 2
Lacking studio and office equipment the f-m console was tested while mounted on the packing case in which it was shipped.

WHEN THE DECISION WAS MADE to install an f-m station in our rural area, a step-by-step installation approach calendar was prepared. The first item on the program was, of course, site selection for the transmitter.

After weeks of tramping and searching, it was decided to locate the entire plant on a 2,500′ peak in a residential section, overlooking and about a half mile from the business section. Factors contributing to its selection were its accessibility, availability of utilities, possibility of nearby quarters for the staff, and proximity to the center of the area we desired to serve. One of its finest assets was an abandoned reservoir situated at the peak, constructed of doubly reinforced concrete and measuring 60′ square and 17′ deep.

The grounds were cleared and a tank prepared as a foundation for the building. This was a stroke of luck as our preparations qualified us for a permit to complete construction under the building restrictions imposed shortly thereafter.

Next Step—The Building

A combination studio-transmitter building was planned to fit the existing foundation, with all necessary working space on the first floor. The entire basement, with the exception of space required for the air conditioning system, was left for future expansion. Everything looked rosy until we found that the FHA's blessing and money in the bank were not adequate to cope with building material shortages.

And so we found ourselves with our building only half completed when the 250-watt exciter unit[1] and studio equipment[2] arrived. These units, incidentally, were the second set off the assembly lines. We felt we could learn quite a bit about the transmitter's operation if we could set it up temporarily, a move which would also add impetus to our promotion campaign. So we asked the FCC if we could put the 250-watt signal on the air under a *Special Temporary Authorization.* Permission

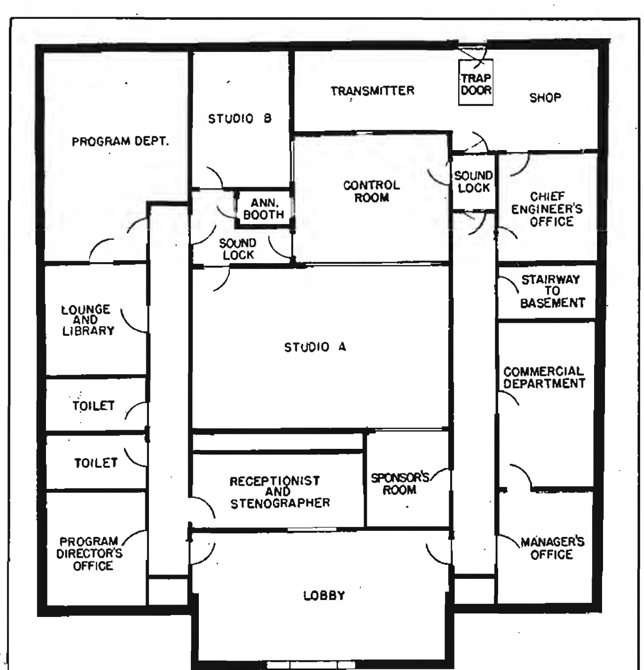


Figure 3
Floor plan of WCFC.

Figure 4
Mr. Yazell applying the finishing touches to the temporary 101.1-mc antenna, a composite turnstile. Temporary studios of WCFC are in building at rear.

Selecting the Site, Developing Makeshift Remedies for Factory-Delay Problems, Preparing for Temporary and Permanent Operation, and Organizing a Dealer-Station Program to Promote F-M.

by GEORGE W. YAZELL

Chief Engineer
WCFC, Beckley, West Virginia

was obtained and a small four-room apartment across the street from our permanent location was leased for the operation.

Incidentally, we are comparatively isolated from the large electronic supply centers, and thus many makeshift arrangements had to be used to establish our service as soon as possible.

Antenna Problem

Our antenna plans provided for the use of a two-bay *donut*[3] antenna mounted temporarily on a 50′ pole, but we were disappointed to learn that this unit would not be available for several months. We therefore decided to use a temporary setup featuring a single-bay turnstile antenna arrangement for our 101.1 mc frequency. The engineering staff designed and constructed the antenna and mounted on it a 40′ pole made up of two lengths of 1½″ galvanized pipe threaded together and guyed with sash cord. The antenna gave excellent service in all weather, with satisfactory reception reported by listeners as far as 37 air-line miles away; this in spite of its power gain of .5. Incidentally the entire antenna cost was in the neighborhood of $25.00.

Polarization

A vertically polarized antenna having nondirectional characteristics would have been simpler to build and would have been approved by the FCC, but since horizontal polarization was to be used eventually and manufacturers are producing horizontal antennas for home installation it was felt the turnstile was preferable.

RG-8/U cable (51.5 ohms) was found to serve nicely for this amount of power. The r-f loss is high enough to cause it to run slightly warm when handling 250 watts at 100 mc. This affords an easy check on proper impedance matching, since standing waves produce noticeable warm spots.

Copper Pipe Dipole Elements

Three-quarter-inch copper pipe was chosen for the dipole elements since it was large enough to make the antenna reasonably broad in frequency response and consequently the length of the dipole elements was not too critical.

Program Service

Program service was initiated August 15, 1946, and continued on a seven-hour-a-day basis until February 7, 1947. The project proved more than successful since it gave the engineering staff an opportunity to become familiar with the operation of the equipment, remedy a few defects that came to light in the early models, and at the same time continue with the preparation of the permanent location.

In addition, public enthusiasm for f-m was heightened and dealers had an opportunity to demonstrate their f-m models.

New Tower

During the period of temporary operation a 242′ tower was erected and the commercial two-bay antenna mounted. The building construction progressed in spite of adverse weather and when the 1-kw amplifier arrived in February all was in readiness to move the transmitter to its permanent location, even though the studios and offices were not complete. After a short silence necessitated by moving the exciter unit to the new building, we returned to the air February 28th, with an effective radiated power of 1,500 watts.

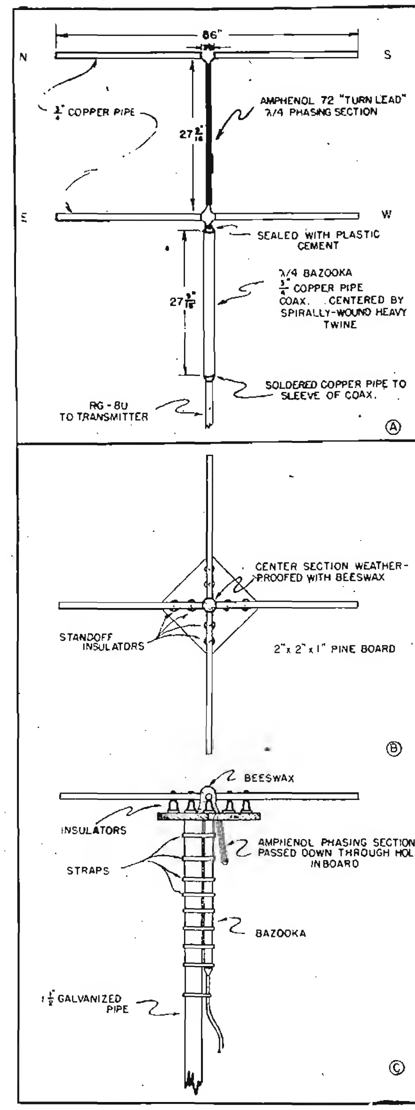


Figure 5

The composite single-bay turnstile antenna. At *a* appears the schematic of the complete antenna; at *b*, the top view; and at *c* the side view.

Coverage

While we have not had an opportunity to accurately determine the extent of our coverage, we have been pleased to receive reports of reception up to 83 miles away, which considerably exceeds the calculated coverage for this power.

Our station, one of the first f-m broadcasters to take the air in West Virginia, was also one of the first to operate in the Southeast.

[1, 2, 3] General Electric.

MAGNETIC PLAYBACK-RECORDER Using Paper Discs

Figure 1
Paper disc recording-playback unit. Note grooved plastic disc.

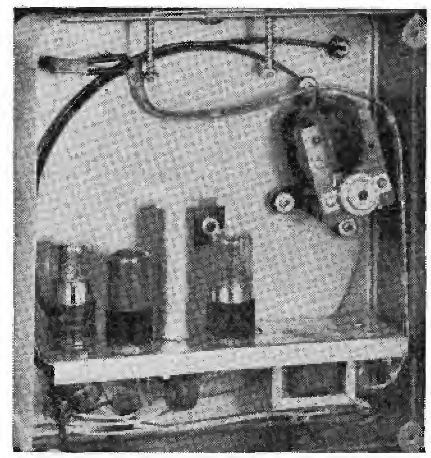


Figure 2
Interior view of the magnetic recorder-playback container.

by JOHN H. JAMES

The Brush Development Co.

Unit Uses Magnetically-Coated Paper Discs That Can Be Folded, Discs Having High Coercivity to Provide Low-Speed Recording.

In developing magnetically-coated paper materials for recording and playback, and studying the applications of various sizes and shapes of papers, it was found that disc-shaped coated stock displayed many possibilities. Possessing magnetizing and demagnetizing properties, the paper was found to be creasable without influencing recording or playback properties.

As a result of this analysis, a paper-disc unit project was initiated, and the device[1] shown in Figure 1 developed.

An interesting feature of the unit is the guide grove. Since it was not

(*Continued on page* 55)

[1] Mail-A-Voice.

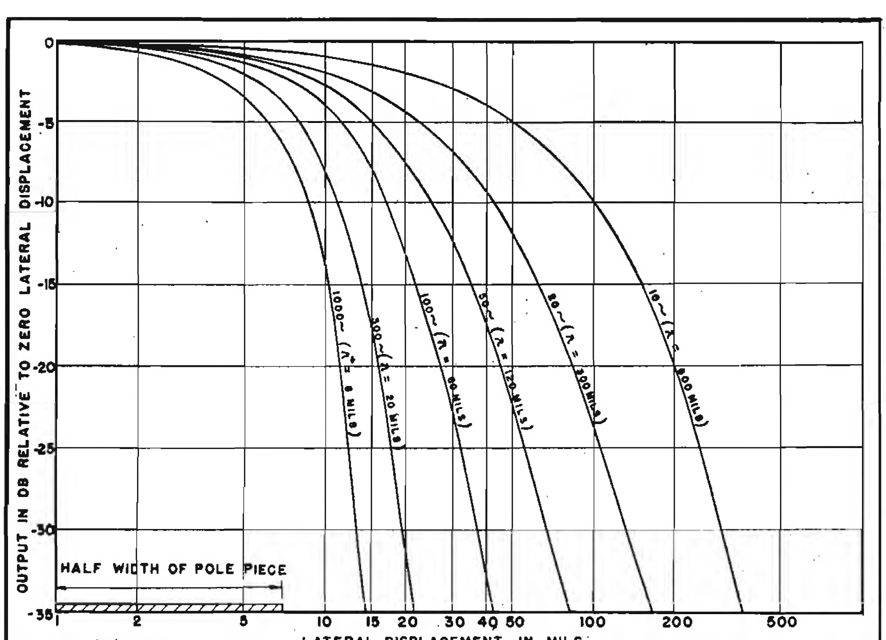
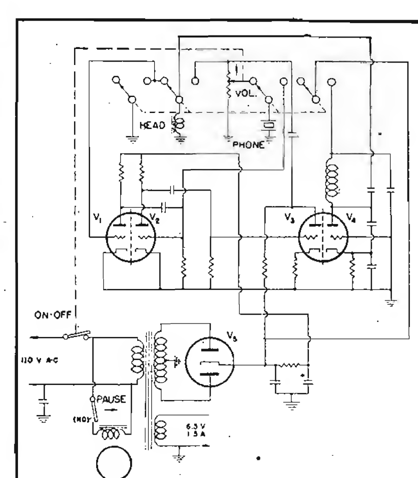
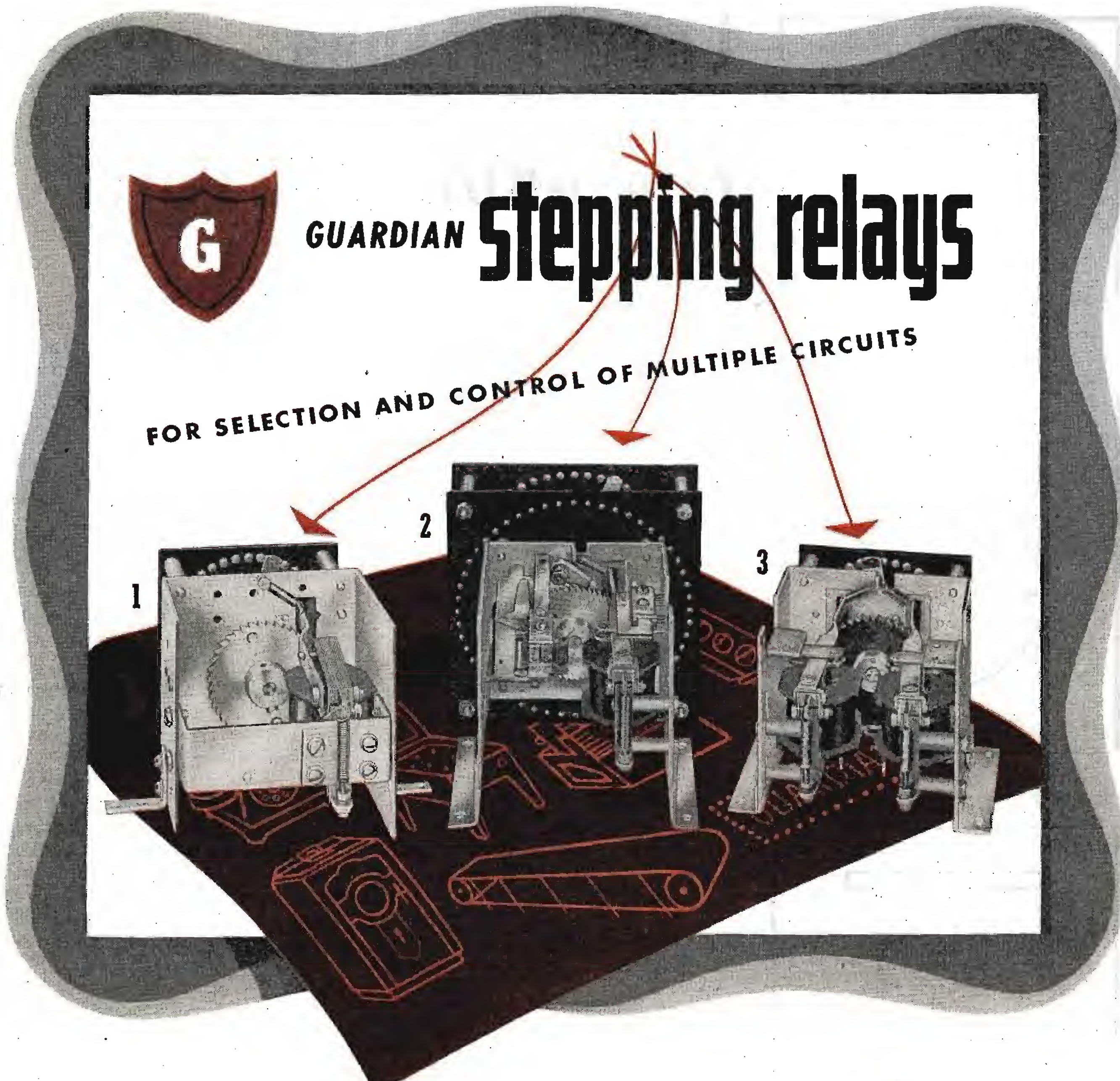


Figure 3
Family of curves showing playback level at different displaceemnts and frequencies for a tape speed of 6 inches per second.

Figure 4
Circuit of the paper disc playback-recorder.




GUARDIAN stepping relays
FOR SELECTION AND CONTROL OF MULTIPLE CIRCUITS
1
2
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Loop Antennas For F-M BROADCASTING

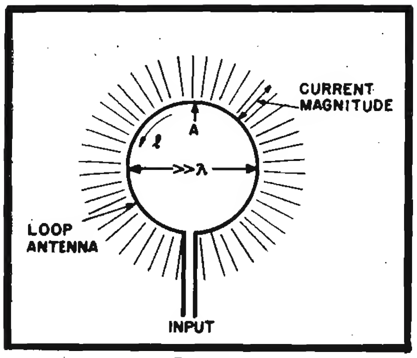


Figure 1
The current distribution around a loop antenna whose diameter is very small with respect to the wavelength, λ, at which it is being used.

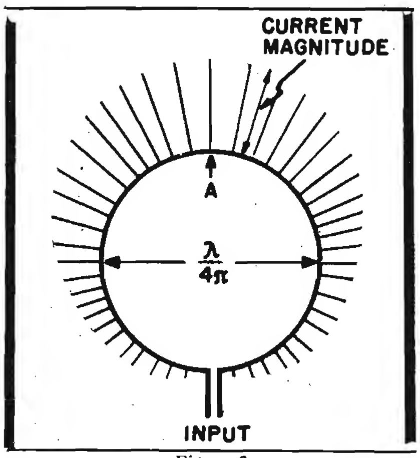


Figure 2
The current distribution around a loop antenna whose circumference is equal to a half wavelength at the frequency being used.

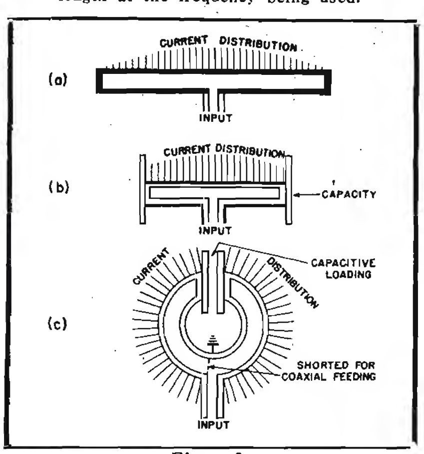


Figure 3
The evolution of the f-m circular antenna from an ordinary folded dipole. At (*a*), folded dipole; (*b*), folded dipole with end capacity added: (*c*), elements of (*b*) bent into a circle.

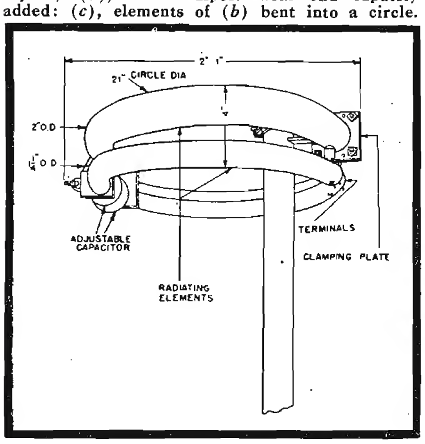


Figure 4
Constructional details of the f-m circular transmitting antenna employing a capacity-loaded folded dipole.
(*Courtesy G.E.*)

THE F-M BROADCAST radiating system usually consists of an array of individual antennas providing horizontally polarized radiation.

It is preferable to install the radiating system on the tallest point in the center of the area to be covered. For maximum efficiency, therefore, the horizontal radiation pattern of each antenna must be omnidirectional. When installation in the center of the area to be covered is not possible, then the horizontal radiation pattern should provide a uniform field strength over the desired region. Each antenna must direct its radiated energy in the horizontal direction; the higher this directivity, the fewer the antennas that have to be stacked to obtain the desired horizontal gain.

Each antenna should be noncritical, easy to feed, simple to adjust and preferably capable of adjustment at the factory before shipment so that no adjustments need be made upon installation. The antenna should not be affected by changes in the weather; but, if it is affected by the elements, such as ice, then precautionary devices, such as deicers, should be provided. Other required antenna features include lightness and sturdiness to allow mounting on a tall mast; the taller the mast, the higher the horizontal gain.

Many antennas have been designed to meet the foregoing requirements, with the basic designs of most employing variations of the horizontal loop antenna or variations of the turnstile antenna.[1]

The Loop Antenna

The horizontal loop antenna, or magnetic dipole as it is sometimes called, has the proper omnidirectional horizontal radiation pattern. It also has some vertical directivity and can be easily stacked in an array. But, an ordinary loop antenna, when used in the 100-megacycle band, has too low a radiation resistance for practical use. The ordinary loop antenna, as used in the lower frequency bands, consists of a number of turns of wire around a loop whose dimensions are very small with respect to a wavelength. Actually, the total length of wire—from one terminal, around the several turns and back to the other terminal—is usually negligible with respect to a wavelength. For 100-megacycles, even if only one turn should be used, the loop dimensions would have to be so small that its radiation resistance would be exiguous; it would be extremely difficult to feed and adjust.

The problem of loop design is mainly one of current distribution in the radiating elements. In Figure 1 is shown a loop antenna whose diameter is very small with respect to the wavelength, λ, at which it is being used. The magnitude of the current around the loop is indicated by the height of the shading around the circumference of the loop. A close approximation of the current distribution can be obtained by assuming that the distribution is the same as that of a lossless transmission line. Hence the loop, for purposes of determining the current distribution, can be assumed to be a lossless transmission line fed at the input and shorted at the point A, equidistant from the balanced input terminals. The distribution will follow the equation

$$I_l = I_{max} \cos \frac{2\pi l}{\lambda} \qquad (1)$$

where l is the distance, measured in the same units as the wavelength, from the point A along the circumference to the point at which the current magnitude I_l, is desired. I_{max} is the current magnitude at the point A, its maximum value. Inasmuch as this distribution follows a cosine curve, for small values of l the current will be constant; this is illustrated in Figure 1 where the diameter of the loop is very much smaller than a wavelength. The radiation pattern for this type of loop is

**Instructor in Graduate Electrical Engineering courses, Columbia University.*

[1]R. F. Holtz, *Super-Turnstile Antenna*, Sixth Annual Conference of Broadcast Engineers, Columbus, Ohio; COMMUNICATIONS, April, 1946.

A Discussion of F-M Antenna Requirements and the Fundamental Application of the Loop Antenna and Its Modifications, the Circular and Square Types, for F-M.

by N. MARCHAND*

Consulting Engineer

Lowenherz Development Company

omnidirectional in the plane of the loop.

When the diameter is increased, to obtain a higher radiation resistance, the current no longer remains constant around the circumference and the radiation pattern begins to distort. For a diameter of $\frac{\lambda}{4\pi}$, about 10″ at 100 megacycles, the current actually falls to practically zero at the input, as shown in Figure 2. The pattern will no longer be omnidirectional.[2]

The F-M Circular Transmitting Antenna[3]

In Figure 3 is shown the evolution of the f-m circular antenna from an ordinary folded dipole. In (*a*) is illustrated an ordinary folded dipole. The current distribution is maximum in the center of the dipole and falls to zero at either end as shown. The dipole can be shortened and the current made more uniform along the length by capacity loading on the ends of the dipole. The effect is similar to the effect of a hat on a vertical broadcast antenna. The capacity takes the place of a portion of the antenna, replacing the low-current end segments. The elements of the shortened, folded dipole are then bent into a circle. The two capacity elements now approach one another forming an air capacitor where provision is made for adjustment of the capacity value. The current is not exactly uniform but it is symmetrical enough to give a substantially omnidirectional pattern.

In Figure 4 appears the constructional details of the final antenna. Its overall diameter is 25″ and it employs 2″ and 1¼″ o-d pipes for the antenna proper.

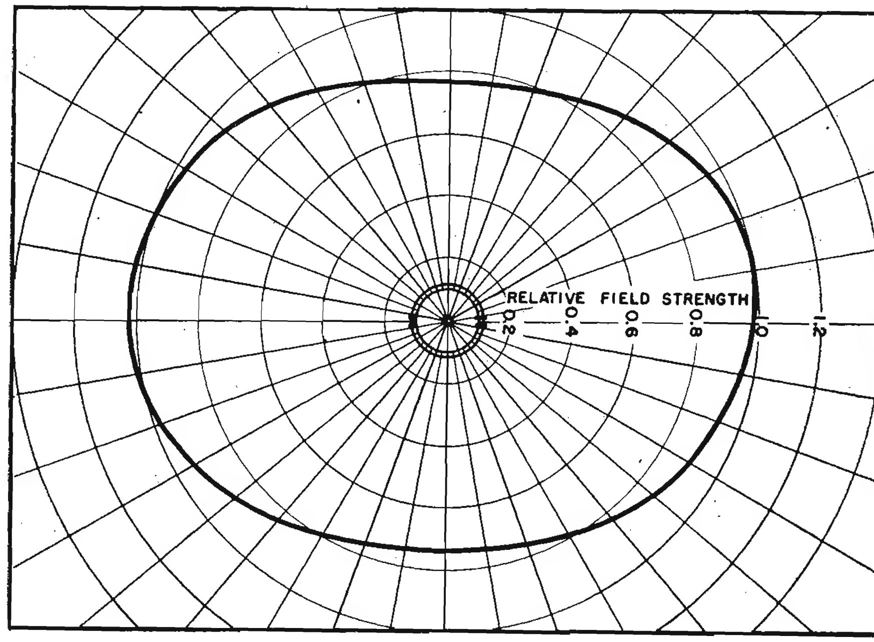
Normally this type of antenna would be fed with a balanced line or, if a coaxial line is used, some type of con-

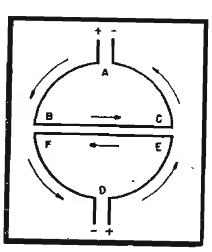
(*Continued on page 62*)

[2]J. B. Sherman, *Circular Loop Antennas at Ultra-High Frequencies,* Proc. IRE; Sept. 1944.

[3]M. W. Scheldorf, *F-M Circular Antenna,* General Electric Review; March 1943.

Figure 5
Experimental horizontal radiation pattern of the circular f-m antenna illustrated in Figure 4.





Figures 6 (above) and 7 (below)
Figure 6: Basic operating principle of the u-h-f loop antenna showing how two small loops are effectively placed back to back to create a larger loop. Figure 7: The two-element u-h-f loop modified to permit coaxial line feed. The coaxial line is fed through the mast that supports the loop proper.
(*Courtesy FTR*)

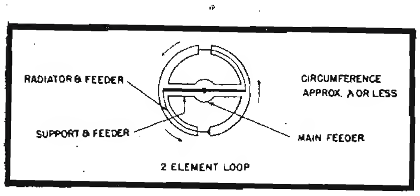
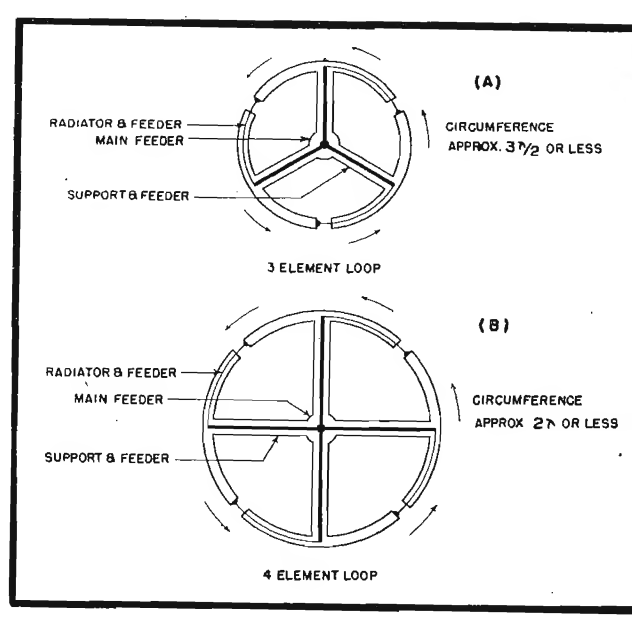


Figure 8
Three and four-element u-h-f coaxial-fed loops. Each added element allows the circumference of the loop to be increased a half wavelength.
(*Courtesy FTR*)



FIVE-STATE ONE-FREQUENCY LINK For Emergency Communications

Use of Single Frequency, 37,900-kc, By Ohio, Western Pennsylvania, New York, Virginia and West Virginia, Provides Coordinated Law-Enforcement Operation Between States, Counties, Car-To-Station and Car-To-Car.

by FRED E. EBEL

"FORGET FREQUENCY ALLOCATION problems. Put all your central stations and mobile units on one frequency!" That was the advice offered five years ago to the Ohio *city police* and *county sheriffs*. They not only adopted the idea, but today the network plan, using 37,900 kc as the frequency, has spread to the neighboring states of New York, Western Pennsylvania, Virginia, and West Virginia.

As for the bogy of interference, operating experience has demonstrated very little annoyance. True, in congested areas where several stations overlap there is some difficulty in this respect, but even here brevity in dispatching has alleviated the condition.

Far offsetting this factor are the tremendous gains in overall efficiency. Law enforcement officials have reported a greater number of apprehensions brought about by better coordination between departments. Flexibility is the keynote of the system. Not only is it possible to communicate county-to-county and car-to-station, but all patrol cars can also contact each other.

The ability to enlist the aid of cars in surrounding areas is particularly important during times of emergency. The recent flood in the Elmira, New York, section demonstrated dramatically the real worth of one-frequency operation. Here flood waters wiped out telephone communication for 36 hours, and the only medium of communication available to city police was 2-way radiotelephone. Yet, because surrounding municipalities and counties could *hear* the fate of their neighbor, sheriffs *four counties away* were able to lend patrol cars to the stricken area.

This vitally-needed assistance enabled authorities to delegate several cars for investigation purposes. A rumor, for example, that a dam was on the verge of breaking was quickly squelched when a dispatched radio car called back that the dam was not only intact but showed no danger of breaking. Had this rumor not been quieted it is quite possible that panic with its tragic consequences could have developed.

But because the communications systems were operating on one frequency there was complete coordination with the result of greatly lessening the destructive effects of a natural disaster.

Cart Theft Reduction

One-frequency operation has also proved its effectiveness in diminishing the number of car thefts. Police of Mansfield, Ohio, for example, have been able to set up efficient blockade systems even after the stolen-car chase has led them beyond the reliable range of the main station. During such emergencies, assistance requests are made car-to-car without the time-consuming procedure of relaying for aid through the central station.

With car efficiency increased approximately 100%, the law breaker, in trying to escape from the 37,900-kc network, finds himself involved in a sort of "chain reaction" where one communication system sets off another.

Plan Originator

The one-frequency plan was conceived by Eugene S. Goebel[1] five years ago. Now throughout New York State, Virginia, and Ohio, alone, there are thirty-nine 2-way radiotelephone central stations[2] with over 400 mobile units.

Over 100 miles of the rich Shenandoah Valley with its numerous gaps and grottoes are radio covered by five central stations located at Staunton, Harrisonburg, Winchester, Waynesboro, and Martinsburg. Other Virginia installations are spotted at Bristol, Petersburg, and Portsmouth.

Romney, W. Virginia, the state police station, monitors 37,900 kc. The Ohio State highway patrol stations also provide a complete tie-in with other systems by monitoring 37,900 kc at Wilmington, Findlay, Massillon, Cambridge, and Columbus. Ohio's municipal police and sheriff's systems reciprocate by monitoring the highway patrol's frequency of 1,730 kc.

Dispatcher Familiarity

Much of the efficiency of the 37,900-kc network can be credited to what might be termed *dispatcher familiarity*. It is only human nature to cooperate more fully with a known voice than with an utterly strange one.

The one-frequency *party-line* system displays another interesting facet—that of preparing communities miles away of a spreading crime wave. If a series of drug-store robberies, for instance, plagues one community, it is the immediate concern of all adjacent communities to set up *traps* at their own drug stores, just in case the hoodlums labor under the delusion that distance lends freedom and virgin territory.

Yes, *one-frequency* operation has proved to be an efficient communications tool for law enforcement.

[1]Acting Director of Sales, Communications and Electronics Division, Motorola Radio.
[2]Motorola.

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Earle C. Anthony, Inc.

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January 6, 1947

Mr. John Hilliard
Altec Lansing Corporation
1161 North Vine Street
Los Angeles, California

Dear Mr. Hilliard:

The purpose of this letter is to tell you about the performance of the type TI-401 Signal Generator and the type TI-402 Intermodulation Analyzer which we recently purchased from you.

We have found the equipment extremely useful for the following operations: 1. Reducing intermodulation distortion in our 50 KW transmitter; 2. Reducing distortion in our speech input equipment; 3. Routine checking of speech input equipment; 4. Indispensable in building special equipment for broadcast purposes such as echo devices, filters, etc.; 5. Indispensable in our Recording Department for checking cutter head performance, playback heads, equalizing amplifiers, compression devices, etc.

We consider it one of our most valuable tools.

Very truly yours,

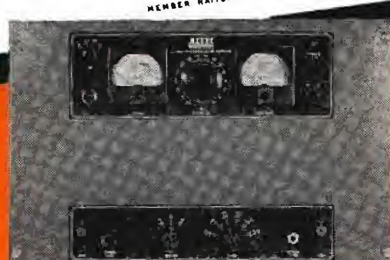
H. L. Blatterman
Chief Engineer

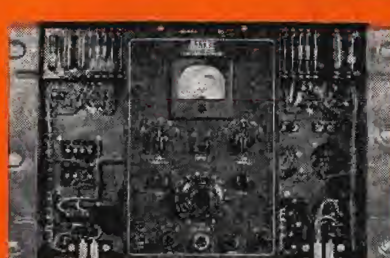
MEMBER NATIONAL ASSOCIATION OF BROADCASTERS

'Indispensable' writes a Broadcasting Engineer about the

ALTEC LANSING

Intermodulation Equipment





A BUSY ENGINEER took time out to write and tell us, point for point, about the tremendous success his station has had with the Intermodulation Analyzer. Its use is not limited to broadcasting stations. Scores of organizations are enjoying similar benefits. Find out how it can be of help to you. Write us for technical data on the TI 401 Signal Generator and TI 402 Intermodulation Analyzer.

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"KEEP ADVANCING WITH ALTEC LANSING"

LATERAL Recording

by W. H. ROBINSON

Technical Advisor
Kasper-Gordon, Inc.

MANY RECORDING setups do not have the facilities to measure the cutter head at the necessary frequencies. An arbitrary choice can be made, which will be quite satisfactory, if the resistance is made nearly equal to the amplifier output impedance.

Several typical setups are shown in Figure 5.

Several methods can be applied to determine when the cutter has the desired characteristics. One, which is tedious, involves the use of a calibrated microscope to measure the amplitudes cut at the different frequencies. In another method a frequency run is played back through a calibrated playback system. A much simpler method is the so-called *Christmas-tree* pattern. This pattern can be seen if a recording of bands of frequencies is made by the head starting at one end of the frequency band to be used, usually fifty cycles, and recording bands at 50-70-100-200-300-500 - 800 - 1000 - 2000 - 3000 - 4000 - 5000-6000-7000-8000-9000 and 10,000 cycles.

Recording a Frequency Run

In making the aforementioned frequency runs, each amplifier component in the setup is put through a test run, and then a composite frequency run of the entire amplifier setup from the input of the system to the output is taken. For the latter run, however, the head should be disconnected, and the output of the amplifier terminated with a resistance load of the proper value. The overall amplifier system should then be adjusted to give linear frequency response over the range in which it is desired to have the cutter work. Care should be taken to insure that the output is as free from distortation as possible. Normally, the output stage should be capable of supplying at least ten or twelve undistorted watts. However, it is much better to use an output stage capable of supplying up to fifty watts of undistorted power.

After the system has been adjusted to the proper frequency response, the cutter head may be connected to the amplifier with its corrective network, and an actual recording can be made of the frequency versus velocity characteristics of the entire system. In making the test, an audio oscillator is fed into the input terminals of the amplifier system. The level is adjusted to that suitable for the head in use. If a *v-i* is used across the output, the level should be adjusted so that the maximum level fed to the head and the corrective network is not greater than that specified by the manufacturer. A simple cut should then be made at the turnover frequency and inspected to see if the level is too high or too low in the groove; this can be ascertained with a microscope. If the groove is not fully modulated, the level can be adjusted in 2 db steps; a check being made with the microscope each time until the correct level is ascertained. It would be wise to reduce the actual top indication used below this value for the complex type of cut, as the meter will not indicate instantaneous peaks. A *v-i* may be used at the input of the system for setting the level, but great care must be taken to insure that the level fed to the head is not too great, otherwise damage to the cutter head will ensue.

Recording at 78 RPM

In the next step another series of frequencies are recorded at 78 rpm, each frequency recorded for ten seconds with approximately five seconds blank groove left between frequencies. If the head travels toward the inside

Figure 4

Ideal recording curve of frequency versus velocity of the stylus point using a 500-cycle turnover point. The stylus velocity is constant above this 500-cycle turnover point while the recorded modulation in the groove has an amplitude which decreases with frequency above this point. Below the turnover point the velocity decreases with frequency and amplitude of the modulation in the groove remains constant.

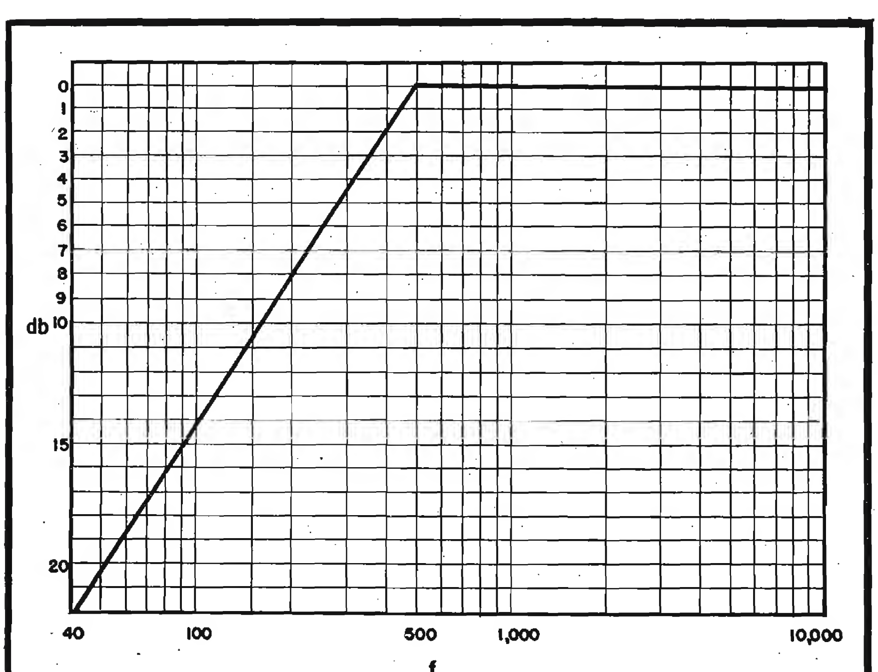
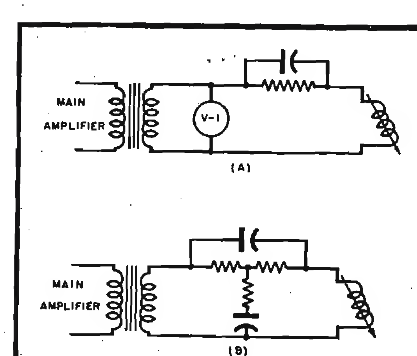
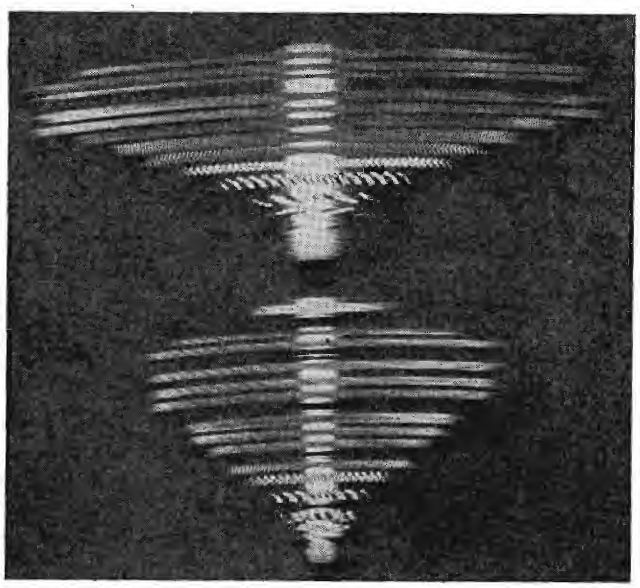


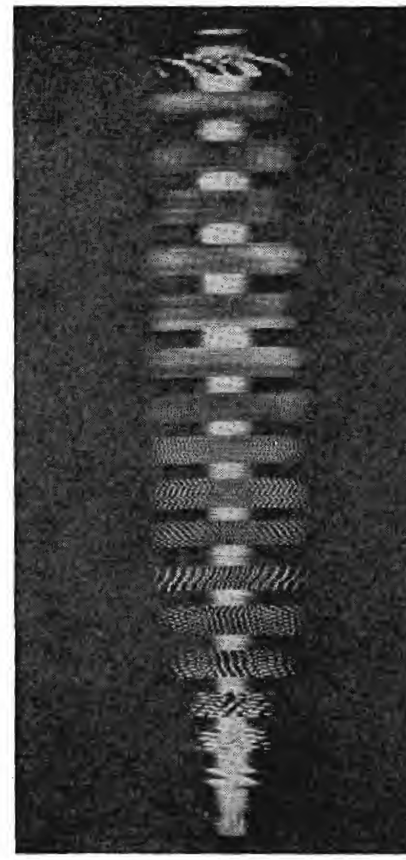
Figure 5

Two variations of equalizers or networks which are used to correct the load offered to the amplifier by the cutting head. In (B) we have a method for correction of a constant load and at the same time correcting for some of the deficiencies in frequency response of the cutter.



Second Installment[1] Covers Measuring Setups, Frequency Run Recordings, Styli, Cutting Angles, Discs, Scratch Filters and Preemphasis.





Figures 6a (above) and 6b (right)

Figure 6a illustrates two response patterns, each from a different head. They are far from those desired as the upper frequencies are decidedly peaked, resulting in shrill response. In Figure 6b appear a near ideal response pattern of cutting assembly and associated equipment as found by methods discussed in paper. The frequencies starting at the small tapered end of the pattern are: 50-70-100-200-300-500-1,000-1,500-2,000-3,000-4,000-5,000-6,000-7,000-8,000-9,000 and 10,000 cycles. The turnover frequency of this system is 500 cycles. The pattern traces the stylus velocity and as can be seen is very nearly constant for the frequencies above 500 cycles where the stylus velocity is supposed to be constant.

of the disc, the frequencies should be recorded in the following order starting at the outside of a 12″ disc: 500 - 10,000 - 9,000 - 8,000-7,000-6,000-5,000 - 4,000 - 3,000-2,000-1,500,-1,000-800-500-300-200-100-70-50 cycles.

After the runs have been made, the disc is taken from the table and placed beneath a strong light so that a distinct pattern can be seen; Figure 6. This pattern actually shows the velocity of the stylus point. Therefore, for frequencies above 500 cycles, it should have straight sides as the velocity is constant. Below this frequency, assuming of course that 500 cycles is the turnover frequency, the sides should slant inward in the manner of a triangle.

Recording Frequency Runs at 78 RPM

The actual response of the head shows up much truer when recorded at 78 rpm than at 33 1/3 rpm, unless a large disc is used for the runs. Analyzing this rather odd situation, we find that when a record is being cut, the stylus cuts a longer length of groove at the outside edge of the disc in a given length of time, than it does as it approaches the inside of the disc; Fig. 7.

The actual ratio of groove length between the outside of the disc and a groove cut 3″ from the center of the disc is 2.625 approximately. This means that for every inch of groove cut at the outside edge of the disc, the stylus cuts a groove only 1/2.625 of an inch at a point 3″ from the center. With the disc passing beneath the stylus at 33 1/3 rpm approximately 2.3 as much information, music, etc., must be cut in a given length of groove than if it were travelling at 78 rpm (78/33 equals approximately 2.3). At the higher frequencies to be recorded a great many excursions of the stylus must take place in a comparatively short length of groove. The stylus must trace the modulation in the groove without distorting it. Now as the groove length becomes shorter and shorter, the inside diameter of the disc is approached. The modulation

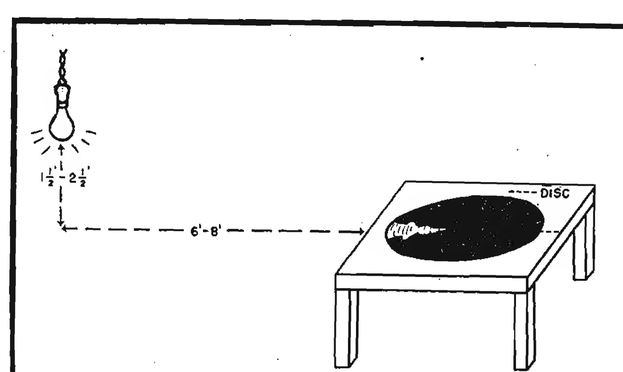


Figure 6

Proper arrangement of light source and disc to evaluate frequency response pattern of a recording system with the so-called *christmas tree pattern*.

[1]*First installment appeared in the February issue of* COMMUNICATIONS.

traces are crowded closer and closer together until a point is finally reached where they are, in fact, so crowded that at ordinary levels the stylus is not able to trace the higher modulation frequencies, so that the playback is able to reproduce them. To overcome this, the higher frequencies must be progressively increased in level as the stylus approaches the center of the disc, thus keeping the response of the recording nearly normal to an inside diameter of seven inches. It is actually a practical impossibility to keep the response exactly normal, especially at the extreme upper frequency limits, but it is possible in this manner to keep the response normal as far as the average ear is concerned. The reproducer needle provides another interesting effect. Its diameter is great enough at the higher frequencies at the inside of the disc so that the actual radius of curvatures of the modulation in the grove is less than the radius of curvature of the reproducer needle point. The reproducer needle has difficulty in following these frequencies under these conditions, further contributing to decreasing frequency response as the inside of the disc is approached.

The equalizer that overcomes this is called the *diameter equalizer*. One of the best-known cutting assemblies has the equalizer mechanically connected to the travelling head so that the equalizing is accomplished automatically. In many setups, the equalizing is done manually. Starting at approximately six minutes in on the recording, for a fifteen-minute recording, the equalizer is adjusted approximately 2 db per minute of cutting. It will be found necessary to reduce the low frequencies slightly below 150 cycles also; this is taken care of in the equalizer design.

As a precaution, the level for recording the frequency run should be approximately 6 db below normal program level. As another precaution it is necessary to see that the head is not fed a continuous voltage for any length of time from the audio oscillator; otherwise there will be a tendency for the head to heat up, resulting in head damage. With complex waves, such as we have when recording a program, the peaks do not occur continually and the head is not working as hard as it is under the above mentioned conditions.

If the cutter travels from the inside to the outside of the disc, the frequency run can be started about four minutes from the outer edge of a 12" disc, and the order of recording of the various frequencies is reversed. The resulting pattern should be the same

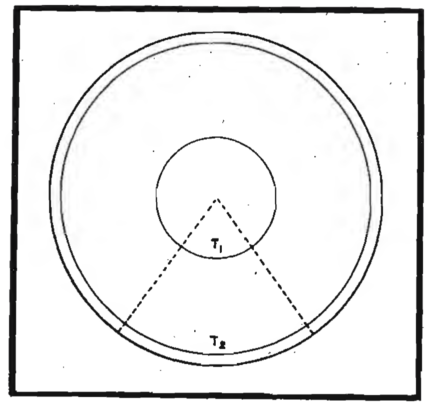


Figure 7

A graphical analysis of stylus travel; for any given length of time the distance travelled by the disc beneath the stylus is considerably shorter near the inner portion of the disc than it is at the outside edge. In the figure T_1 equals T_2 and refers to the time it takes for the disc to travel the distance between the dotted lines intersecting the two grooves. This variation in the length of groove cut in a given time as the cutting stylus approaches the center of the disc results in the modulation being compressed more and more as the center of the disc is approached. This combined with the fact that the disc travels 1/2.3 as fast at 33 1/3 rpm as at 78 causes the difficulty in recording and reproducing the higher frequencies when cutting at the slower speed.

as the one previously shown. In many cases, the pattern shows marked deviation from the proper pattern, and should be corrected. If a peak shows up it will usually be between the turnover frequency and the highest frequency to be recorded. This can be corrected by equalizing the amplifier, or correcting the cutter head filter to bring the response at the point back to normal. It is not within the scope of this article to discuss equalizers or corrective filters. However, many heads as they age develop a peak in the range between 500 and 10,000 cycles, due to various reasons such as mishandling, aging of the damping material in the head, dirt collecting on the armature, etc. The proper procedure is, of course, to send the head back to the manufacturer for adjustment. If this is not feasible, the corrections mentioned previously may be applied. It is always better to have a cutter head that operates properly than to try to get around the faults by corrective measures. The cutter head is a delicate instrument and should be treated with the utmost respect if the best results are to be obtained from it.

Styli

There are several types of styli in use today; stellite, steel, and the stylus with an aluminum shank and a sapphire cutting point. The last mentioned is the best from the standpoint of a quiet groove, frequency response, and length of life. The all steel stylus becomes noisy after about fifteen minutes of use and cannot be resharpened, while the sapphire will last about six to ten hours of recording time and can then be resharpened at a fraction of the cost of a new sapphire. The initial cost of the sapphire is approximately six to eight times the cost of the steel stylus, but in the long run is much more economical than the steel stylus. The stellite stylus ranks next to the sapphire.

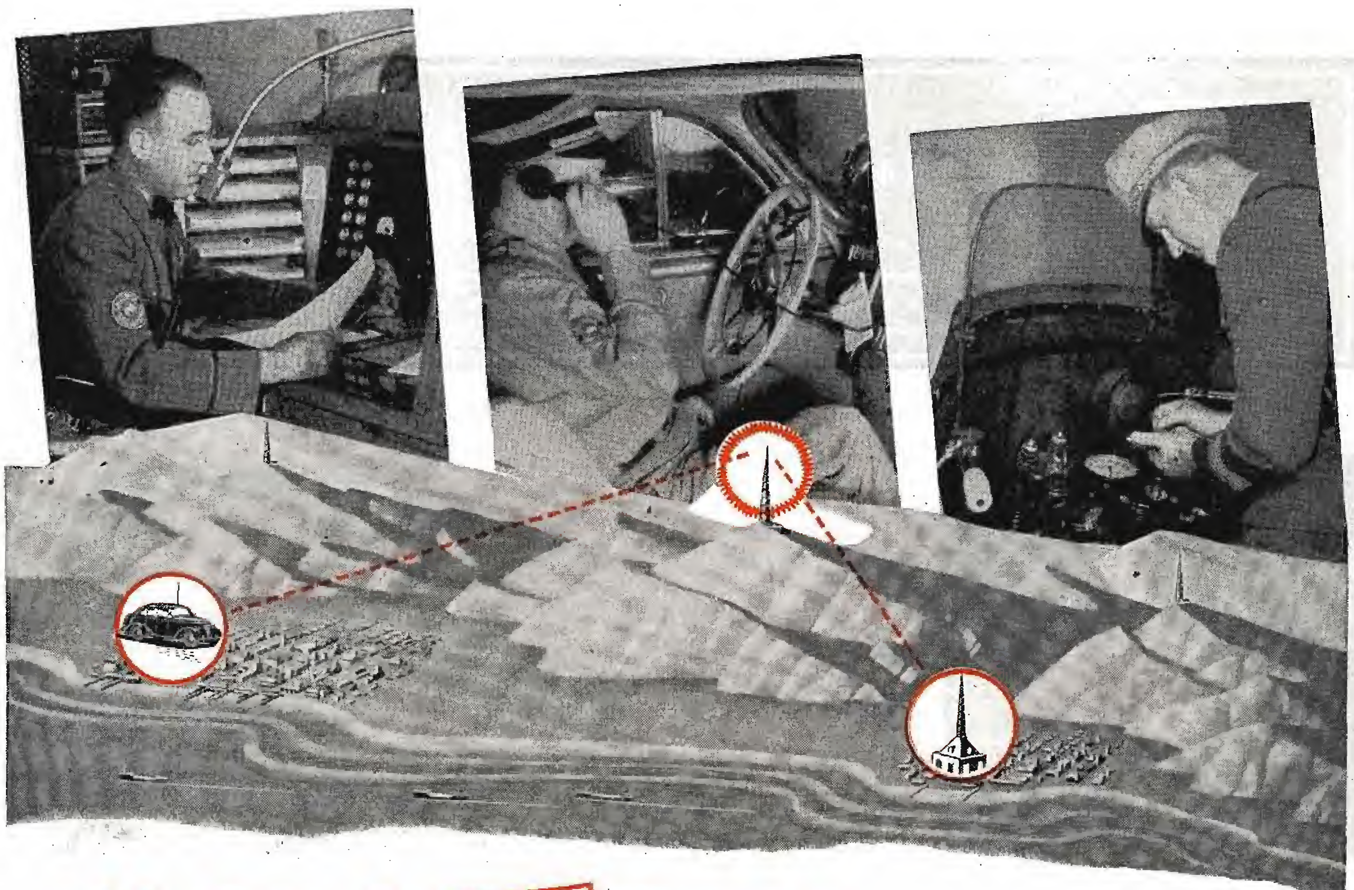
The styli used today in the instantaneous recording systems have a flat on the shank which faces the front so that it can be held firmly in place by the set screw. It is impossible to get the stylus in the chuck improperly if any care is used at all.

The stylus should be inserted all the way into the chuck. The practice of some technicians of drawing the stylus part way out of the chuck to get the proper cutting angle is not a good one. As we have already discovered, it requires considerable care to achieve high quality records and it doesn't take a very high degree of carelessness to cause considerable loss of high-frequency response in the recording process. Unless the stylus is inserted as far as possible into the chuck, it is possible for it to dampen the vibrations at the higher frequencies. Another *must* is that the set screw must be tightened firmly to ensure that the stylus is held firmly in the chuck. Any play or looseness of the stylus will cause considerable loss at the higher frequencies and at the same time create undue distortion. The angle of the stylus point with respect to the surface of the disc being cut is also important. A wrong cutting angle can cause unnecessary noise in the cut and can even, in extreme cases, be the cause of ruining the point of the stylus.

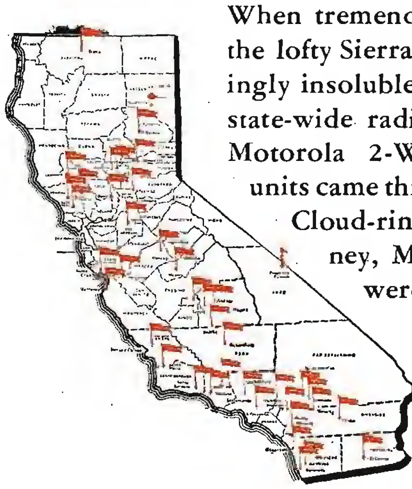
Cutting Angles

It is a simple matter to adjust the cutting angle of the stylus properly. Most cutting assemblies have some provision for adjusting this angle. The correct procedure is to place a disc on the cutting table and then set the assembly on the table in position for cutting. The cutting head is then moved to a position near the outside edge of the disc, the cutting head gently lowered so that the stylus point rests on the surface of the disc (the table is of course stationary). Now with the eye level with the top of the table on the side opposite that on which the stylus rests, we sight across

(*Continued on page 58*)



Motorola F-M Radio Makes MOLEHILLS out of MOUNTAINS!



When tremendous natural barriers like the lofty Sierra Nevadas presented seemingly insoluble problems in California's state-wide radiotelephone coverage . . . Motorola 2-Way F-M Radiotelephone units came through with all the answers. Cloud-ringed giants like Mt. Whitney, Mt. Shasta, and Mt. Lassen were, as effective obstacles to transmission and reception, leveled to the ground. As a result, California's Highway Patrol radiotelephone communications rank among the country's most efficient, with 485 two-way unit patrol cars and 377 one-way unit motorcycles patroling 58 counties.

In 36 states and over 2,500 communities throughout the United States, Canal Zone, and Hawaiian Islands, police F-M 2- and 3-way radiotelephone installations have proved the remarkable skill and experience displayed by Motorola engineers. Your state, county, city or community can take advantage of this experience. For Full Details, Write Today.

GALVIN MFG. CORPORATION • CHICAGO 51

COMMUNICATIONS AND ELECTRONICS DIVISION

F-M & A-M HOME RADIO • AUTO RADIO • AUTOMATIC PHONOGRAPHS • TELEVISION • F-M POLICE RADIO • RADAR • MILITARY RADIO

George E. Sterling, who has been named FCC chief engineer

WE WERE QUITE PROUD to hear that our good friend George E. Sterling, VWOA oldtimer, has been appointed chief engineer of the FCC. Formerly assistant chief engineer in charge of the FCC Field and Research Branch and wartime head of the Radio Intelligence Division, GES succeeds VWOA member George P. Adair who has resigned to open up a consulting engineering office in Washington.

GES is quite an old timer, having been in radio since 1908 when he began pounding brass as a ham at his home at Peaks Island Portland, Maine. In 1923 he entered government service as a radio inspector in the Bureau of Navigation of the Dept. of Commerce. He became an inspector in charge of the third radio district of the Federal Radio Commission in 1935. And in 1937 he was appointed assistant chief of the FCC Engineering Department Field Division in Washington, D. C.

The war years saw him quite active on many fronts of the government communications operations. In 1940 he was named chief of the National Defense Operations Section of the Field Division and in 1942 he became chief of the Radio Intelligence Division, as well as assistant chief engineer. In 1945, he was named head of the Field and Research Branch of the FCC.

In 1946, GES served as a delegate of the Provisional International Civil Aviation Organization at the demonstrations of radio aids to air navigation in London.

Thousands of amateurs and engineers have read GES' book "The Radio Manual," the fourth edition of which is now being prepared.

Good luck GES!

•

WALTER EVANS, another VWOA oldtimer, who is vice president of Westinghouse Electric and vice president and general manager of the Westinghouse radio stations, has received the Army Certificate of Appreciation for his wartime radio activities.

Under WE's direction, Westinghouse manufactured over $400,000,000 worth of electronic equipment for the Army and Navy, which included proximity fuzes, airborne search radar, land based aircraft warning radar, etc.

WE began his operating days in 1921 with KYW, Chicago. He became successively chief engineer and general manager, and in 1932 was placed in complete charge of all Westinghouse broadcast stations. He was named vice president of Westinghouse in 1942.

C. C. RICHELIEU, who became a commercial operator in 1928 serving aboard numerous ships, is now district manager for the Simplex Recording Company in Milwaukee, Wis. . . . W. Q. Ranft, chief engineer of WFBR in Baltimore, Md., recently took charge of the WBBR f-m station. . . . Fred McDermott, a pioneer radioman in the United States Navy, recently returned to his assignment with A. T. & T. Glad to have you back Fred . . . . E. N. Pickerill, former chief aboard the Leviathan, a veteran member of VWOA, started in radio in 1905 with the American De Forest Company. He then went with United Wireless, Marconi Wireless Telegraph Company, RCA and RMCA, and is now with RCAC at Broad Street. ENP is one of the oldest active pioneers on the VWOA rolls. . . . Happy to learn that Gilson V. Willets, chairman of the San Francisco chapter and charter member of VWOA and his wife, who were both very ill, are now on the road to recovery. . . . Veteran member Edward G. Raser, secretary of the Delaware Valley Radio Association and director of the Atlantic division of the ARRL is on the prowl for oldtime radio equipment. . . . Life member H. A. Steinberg who continues his numerous jaunts about the country in behalf of his radio accounts, invariably puts in a good word for VWOA. . . . A. H. Waite, who saved Admiral Byrd's life back in 1934 was aboard the U. S. S. Mount Olympus as civilian radio engineer for the Byrd Antarctic Expedition . . . Joe Graham of Woburn, Mass., is stationed at the FCC monitoring station at Millis, Mass. . . . Max Ortelet, a real oldtimer, is at the Tropical Telegraph land station WBF at Hingham, Mass. . . . Received a note from Monte Cohen from Longmeadow, Mass., and Charles E. Maps of the Westchester Telephone Company. . . . Edward Oberle is conducting a radio-engineering consulting practice in Jacksonville, Fla.

Walter Evans, Westinghouse vice president, who recently received a Certificate of Appreciation from the U. S. Army.

READY NOW

IN ANSWER TO HAMS' DEMANDS

EST. 1914

Hams around the world have been National's collaborators in creating the NC-173—ready now after five years of intensive research. Here are some of the advantages this 13-tube superheterodyne receiver offers:

- The NC-173's newly designed adjustable threshold double diode noise limiter—working on *both phone and CW*—has an extremely high limiting efficiency because of the short recovery time.

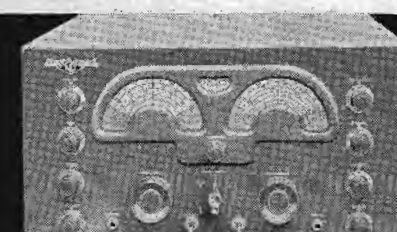
- Voltage regulated circuits give the NC-173 high stability and less drift for changes in powerline voltage. The pitch of code characters barely changes—even over extended listening periods.

- The S-meter circuit allows signal strength recordings to be taken on either *phone or code*.

- Works equally well on coaxial feed-line, single-wire, directional or balanced antenna.

- AC powered. Will also operate on battery for portable or emergency use—110/120 or 220/240 volts, 50/60 cycle. Frequency range .54 to 31 and 48 to 56 MC. (Includes calibrated band spread on 5, 10, 11, 20, 40 and 80 meters).

- Ask your dealer to let you see and hear the new moderate-priced NC-173.



THE NATIONAL NC-173

NATIONAL
COMPANY, INCORPORATED
MALDEN, MASS.

THE MOST DISTINCTIVE NAME IN RADIO COMMUNICATIONS

The Industry Offers

FAIRCHILD LATERAL PICKUP ARM

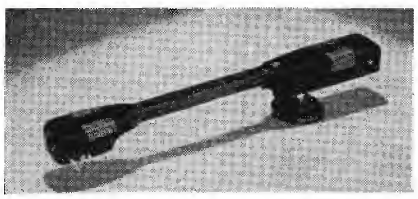
A lateral pickup arm, 542-M1, combined with dynamic cartridge and equalizer, has been developed by the Fairchild Camera and Instrument Corporation, Jamaica, N. Y.

Arm is balanced to reduce skating over the record.

Mounting base of pickup, which is available with either a 3-mil or a 2.2-mil stylus tip, is adaptable to varying heights of turntable platters by a setscrew adjustment. The extra length from pivot point to stylus tip is said to reduce distortion resulting from tangential tracking error.

Frequency response said to be ±2db in 30 to 10,000-cycle range.

Stylus pressure, 25 grams; center of base to stylus tip, 12½"; overall length, 14½"; diameter of base, 3"; and height of base, 3¼".



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DU MONT TELEVISION SYSTEM

A television station setup using a translucent rear projection screen, special prism and 16-mm projector operating at 30 frames per second instead of the conventional 24 frames, and standard field image orthicon cameras, has been developed by the Allen B. Du Mont Laboratories, Inc.

In operation, the 16-mm projector is mounted together with the prism in the rear of the translucent screen which can either be mounted in a portable frame or built into the main studio wall separating the projection room from the main studio. The image orthicon camera which is used to televise both live and film programs is moved directly in front of the translucent screen and focused on the projected image.

* * *

HYTRON INSTANT-HEATING V-H-F BEAM PENTODE

An instant-heating filamentary-type 15-watt transmitting beam pentode, type 5516, has been developed by the Hytron Radio and Electronics Corp., 76 Lafayette Street, Salem, Massachusetts. Designed for v-h-f mobile equipment, the tube can be used as a class C frequency multiplier or as a class C amplifier requiring no neutralization in properly designed circuits operating up to 165 mc. Filament is rated at 6.0 volts.

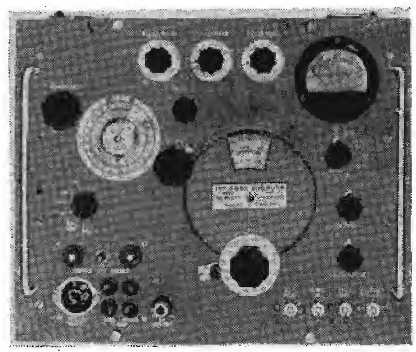
Tube has a zirconium-coated plate, gold-plated control grid, and carbonized screen grid. Three separate base-pin connections to the filament center tap provide for low cathode lead inductance.

HEWLETT-PACKARD U-H-F SIGNAL GENERATOR

A wide band u-h-f signal generator, 616A, for the 1,800- to 4,000-mc bands, featuring direct reading frequency and voltage scales, c-w, f-m pulsed or delayed pulse output, has been announced by Hewlett-Packard, Palo Alto, Calif.

The generator utilizes a resonant-cavity, reflex-klystron oscillator. R-f output may be directly set and directly read, either in microvolts or db, on output dial. Accuracy of frequency calibration is said to be within ±1%; stability of the order of 0.005% per degree C in ambient temperature.

R-f output ranges from 0.1 volt to 0.1 microvolt, or 7 dbm to 127 dbm.



* * *

G.E. AIRCRAFT TRANSMITTER-RECEIVER

A 9½" long two-way transmitter-receiver, type AS-1C, has been designed by the transmitter division of G. E.

Designed as a companion unit to the AS-1B radio for the private plane, the new unit provides two-way tower and radio range station communication as well as broadcast reception.

Operates directly from a twelve-volt power system. Features of receiver (200-420 kc and 500-1,500 kc) include avc, directional loop antenna arrangement, and a voice filter.

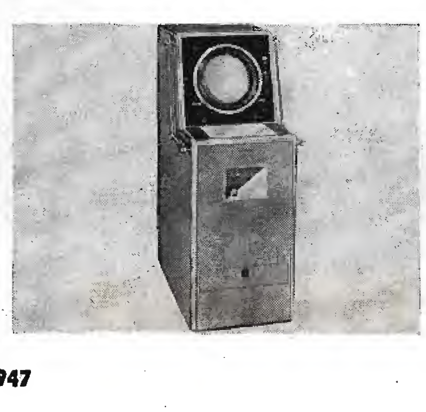
The transmitter has a 12-watt carrier output and operates at 3,105 kc, crystal controlled.

* * *

DE MORNAY-BUDD MARINE RADAR

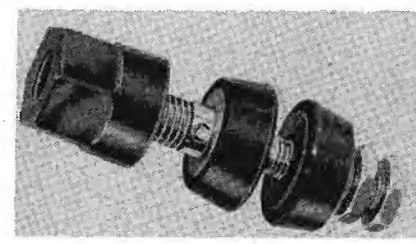
Marine radar equipment for ocean freight and passenger vessels, featuring a range of from 100 yards to 32 miles has been announced by DeMornay-Budd, Inc., 475 Grand Concourse, New York 51, N. Y.

Has a peak pulse power output of 18 kilowatts. Units have a 12" screen and display U. S. geodetic charts on a companion screen; microfilm copies of charts are made on 70-mm color film to present a true image of charts, including correct color of the various indicators such as bouys and channels.



SUPERIOR ELECTRIC BINDING POSTS

A multi-purpose binding post (type DF30) providing five ways of connecting leads has been announced by The Superior Electric Company, 44 Church Street, Bristol, Connecticut. Five connections are—permanent clamping of wire up to size 12 through center hole; looping of wire around the center shaft and clamping; plugin connection of a standard ¾" center banana plug; clip-lead connection by removing the hexagonal shaped phenolic head; and spade lug connection. Binding post can be used on panels up to ¼" thick. Metallic components are recessed. Current-carrying capacity is 30 amperes.



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SYLVANIA BEAM POWER TETRODE

A v-h-f beam-power tetrode type 3D24, for use up to 125 mc, has been announced by the electronics division, Sylvania Electric Products, Inc., 500 Fifth Avenue, New York 18, N. Y.

Tube has a carburized thoriated tungsten filament rated at 6.3 volts, 3 amperes. Number one grid is of the vertical bar type with two support leads; number two grid is connected to an internal heat-reflecting shield to provide a low grid-to-plate capacity characteristic.

No metallic getter flash is deposited on the bulb.

Typical operating conditions are: Plate voltage, d-c, 1,500; control grid voltage, d-c, –300; screen grid voltage, d-c, 375; plate current, d-c, 90 ma; control grid current, d-c, 10 ma; screen grid current, d-c, 22 ma; peak r-f grid input voltage, 400; full driving power, 4 watts; and plate power output, 105 watts.

* * *

LANGEVIN PLUG-IN AMPLIFIERS

Plug-in type pre-amplifiers (10"x2"x5"), type 116-A, and monitor amplifiers (10"x3¼"x5½"), type 117-A, have been developed by The Langevin Co., Inc., 37 W. 65th St., New York 23.

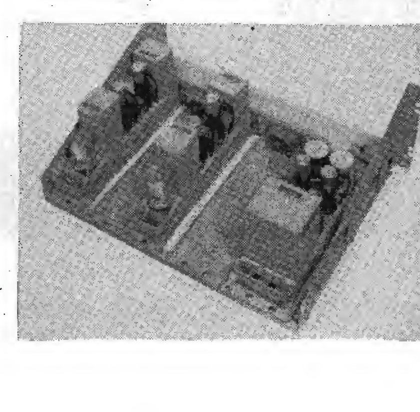
The 116-A has a gain of 40 db with provision for adjusting to 34 db. Output power is said to be +18 dbm (.063) with less than .5% rms total harmonic distortion over the range 50 to 15,000 cycles, and less than 1% total distortion over the range 30 to 15,000 cycles; output noise equivalent to an input signal of –124 dbm over a band width of 20,000 cycles.

Input source impedance, 30/150/250/600 ohms; output load impedance, 150 or 600 ohms.

Uses two 1620 tubes.

The 117-A has a gain of 50 db. Output power is said to be +30 dbm with less than .5% rms total harmonic distortion over the range 50-

(*Continued on page* 59)



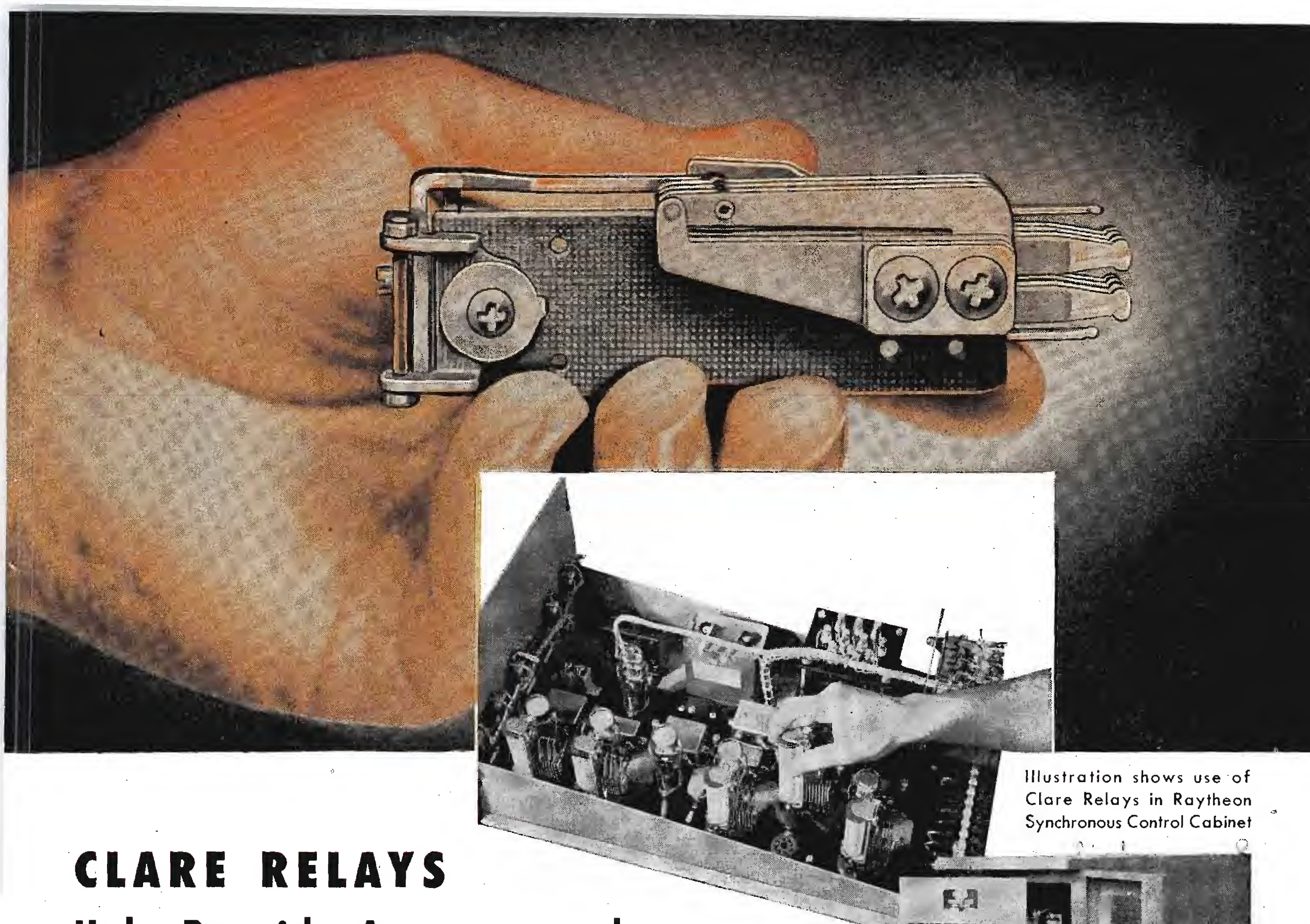
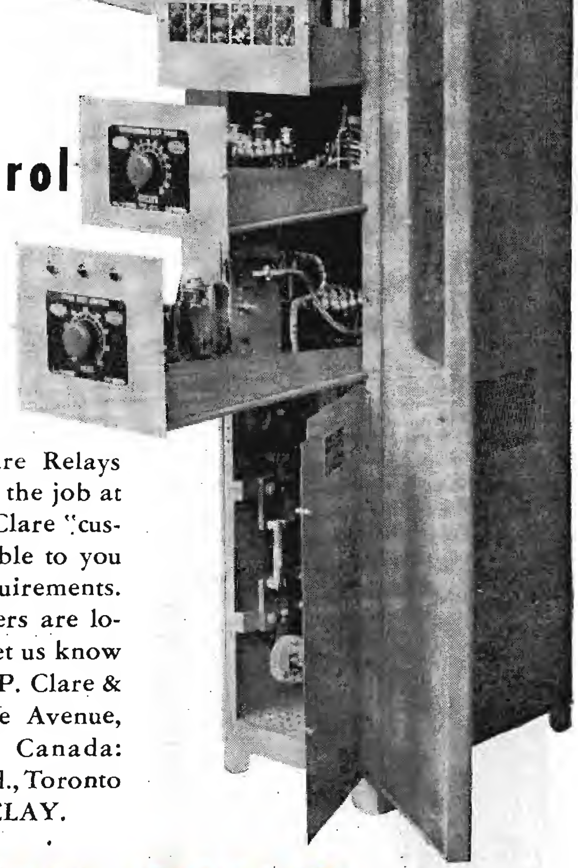


Illustration shows use of Clare Relays in Raytheon Synchronous Control Cabinet



CLARE RELAYS

Help Provide Accurate and Dependable Operation for RAYTHEON Electronic Welding Control

● Resistance welding is speeded up by this new Raytheon Electronic Synchronous Control. Spot, seam or pulsation timing are also provided from the same cabinet.

Clare Relays were chosen by Raytheon Manufacturing Company of Waltham, Mass., for this new modern unit because of their accurate, efficient and dependable operation. Clare compact, clean-cut design met Raytheon demands that all components contribute to the ease and convenience of use, the flexibility of application and streamlined appearance.

Four Clare Type "C" d.c. Relays and one Clare Type "A" a.c. Relay, shown in this drawer type sequence timer, are supplied by Clare with coil windings, contacts and all special adjustments to meet exact Raytheon requirements.

This use of standard Clare Relays with modifications to meet the job at hand is what we mean by Clare "custom-building." It is available to you for your unusual relay requirements. Expert Clare sales engineers are located in principal cities. Let us know your problem. Address: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical and Industrial Use

News Briefs

INDUSTRY ACTIVITIES

On May 17, the newly created North Atlantic Region of the IRE, composed of the Connecticut Valley Section and the Boston Section, will sponsor an all-day radio engineering meeting at the Hotel Continental in Cambridge, Massachusetts.

Scheduled for the meeting are six technical papers:

Low Drag Aircraft Antennas for 2 to 18 mc; John V. N. Granger, Student, Harvard University.

The Commercial Design of Geiger-Mueller Counter Tubes; Herbert Metten, Sylvania Electric Products, Inc.

Recent Developments in Frequency Stabilization of Microwave Oscillators; William G. Tuller, M. I. T.

A V-H-F Bridge for Impedance Measurements at Frequencies Between 20 and 140 mc; R. A. Soderman, General Radio Company.

Design Problems of F-M Receivers; Aldo Miccioli Associate of Dale Pollack.

Wartime Developments in Wave-Guide Theory; Julian S. Schwinger, Professor, Research Laboratory of Physics, Harvard University.

Research and engineering facilities of the Farnsworth Television and Radio Corporation have been moved to enlarged quarters at the Fort Wayne plant.

The Sangamo Company, Limited, Leaside, Ontario, Canadian affiliate of the Sangamo Electric Company, Springfield, Illinois, will produce mica and paper capacitors, including plastic molded paper tubulars.

Aircraft Radio Corporation, Boonton, N. J., has delivered ten v-h-f omni-directional range receiving systems (type 15) to the CAA.

Systems are being installed in the CAA's fleet of regional inspection aircraft.

Under its 1947 program the CAA plans to activate 288 v-h-f radio range stations. Of these, 218 will be of the omni-directional type. Remainder of stations will be the two-course visual-aural type, similar to the over-the-mountains airway type that has been in operation for some time between Denver and Las Vegas.

Measuring instruments manufactured by the Boonton Radio Corporation, Boonton, N. J., will be distributed outside of the United States by the RCA International Division.

The Marine Division of Mackay Radio and Telegraph Company will supply and install commercial radar (Mariners' Pathfinder type made by Raytheon) on the tankers of the Union Oil Company of Calif.

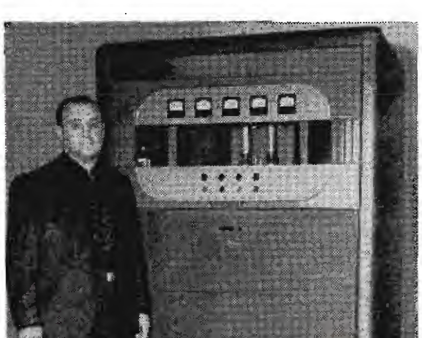
The equipment operates on 10 centimeters.

Mackay Radio is authorized sales and service organization within the United States for the Raytheon radar unit.

KKLA, Los Angeles f-m broadcast station, has installed a 10-kw Collins f-m transmitter.

KKLA will transmit on 93.7 mc with an effective radiated power of 48 kw, and expects to apply for a 60-kw assignment.

KAKC-FM, Tulsa, Okla., recently went on the air with a Collins 250-watt f-m unit. Station is authorized to use 3,000 watts f-m at 94.9 mc. The 3-kw f-m amplifier will be added later.



C. Harvey Haas, chief engineer of KKLA, and the f-m exciter unit.

The E. F. Johnson Company, Waseca, Minnesota, has purchased the Gothard line of indicator lights from the Gothard Manufacturing Company, Springfield, Illinois.

The Gothard line is now being manufactured at the Johnson plant in Waseca.

Collins Radio recently consigned one of its transmitters to the FCC in Washington to be used in conjunction with 30-kc channel separation tests.

Transmitter will eventually be used for broadcasting by WOOK, United Broadcasting Company, Silver Springs, Maryland.

Wells Sales have moved to 320 N. LaSalle Street, Chicago.

A plan to provide colleges throughout the country with low-cost low-powered f-m broadcast transmitters and use educational f-m channels has been proposed to the FCC and the U. S. Office of Education by G. E.

The station plan calls for use of transmitters with a power output of 2½ watts; this would be the modulator section of large G. E. f-m units.

The diminutive transmitter would provide a five- or six-mile range and is enough to cover most college campuses, fraternity or sorority houses and surrounding student homes.

G. E. points out that these transmitters can be enlarged to a full-size educational f-m station up to 50 kw, and eventually become part of statewide networks.

Bolinao Electronics Corporation, Manila, R. P. I., have established offices at 50 Broadway, New York 4, N. Y.

James B. Lindenberg is vice president in charge of Philippine operations. His staff is said to consist of three American electrical and radio engineers and 50 Filipino technicians and sales personnel.

The home offices of the company are in the China Bank Building, Manila.

Sola Electric Co., 2525 Clybourn Avenue, Chicago 14, Ill., has opened a New York City office at 50 Church Street, New York 17, N. Y.

The Broadcast Equipment Division of Raytheon presently located in Chicago, will be moved to the main plant at Waltham, Mass.

* * *

PERSONALS

Leonard Cramer, executive vice president of Allen B. Du Mont Labs. has been named general manager of WABD, Du Mont's video station.

Donald MacGregor, formerly executive vice president of Webster-Chicago Corporation, has been elected vice president in charge of production of the Zenith Radio Corp.

Austin C. Lescarboura, well-known editor and industrial advertising consultant of Croton-on-Hudson, N. Y., has been awarded the French order of "Officier de l'Instruction Publique." The citation carries the Paris date of January 15th, 1947, and is in recognition of technical services rendered for many years past.

D. A. Myer has become technical field director of Westinghouse Radio Stations, Inc.

George E. Hagerty succeeds Myer as engineering manager.

Royal V. Howard, vice president of Associated Broadcasters, San Francisco, has been named NAB director of engineering.

Arthur J. Sanial has resigned as chief engineer of the Atlas Sound Corp. and is now devoting his full time to consulting engineering in loudspeaker and sound-system design, measurement, etc., at 168-14 32d Avenue, Flushing, N. Y.

E. F. Lazar has been appointed director of the Sperry Gyroscope federal department to handle all contractual relations with military departments of the government. **George Tate,** formerly director of district sales and service, is the new director of export sales. **A. R. Weckel,** formerly aeronautical sales manager, has been appointed director of commercial sales.

Richard W. Hubbell has resigned from the executive staff of Crosley Broadcasting to open a television, radio and motion picture consultant office, Richard W. Hubbell and Associates.

Temporary headquarters are in Cincinnati at 140 West Ninth Street. Permanent headquarters will be in New York at 2101 International Building, 630 Fifth Avenue.

A Hollywood o..ce, 3201 Tareco Drive, will also be opened with H. Russell McCune in charge.

E. N. Wendell, vice president in charge of sales, Federal Telephone and Radio Corporation, was recently elected a fellow of the IRE.

William G. Ellis has been named manager of industrial electronics sales of the RCA engineering products department.

William F. Barnes is now manager of the RCA tube mounts and accessories sales section.

Kenneth B. Shaffer, formerly renewal sales field representative for the RCA tube department in Cincinnati, has been transferred to the Harrison, N. J., headquarters where he will supervise the sale of parts to tube and parts distributors.

Dr. Wilbur Reed LePage, formerly senior research engineer of Stromberg-Carlson, has been appointed associate professor of electrical engineering in the College of Applied Science, Syracuse, New York.

Professor Igor M. Plusc, formerly mathematician and physicist for the Colonial Radio Corporation of Buffalo, New York, has been appointed assistant professor of electrical engineering in the College of Applied Science, Syracuse University, Syracuse, New York.

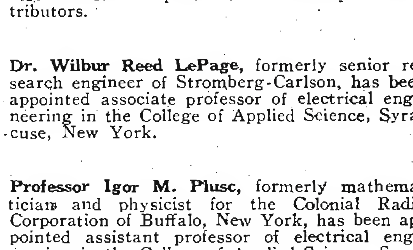
Clyde H. Schryver, Merchandise Mart, Kansas City, Missouri, has been named sales representative for Eimac tubes in Missouri, Kansas, Nebraska (east of the 100th meridian), and Iowa, except Cedar Rapids.

Pierre F. Marshall has been named advertising manager for The Magnavox Company.

Dr. Vladimir Kosma Zworykin is now vice president and technical consultant of the RCA Laboratories Division, RCA.

Dr. Zworykin has been director of the Electronic Research Laboratory of the RCA Laboratories Division, Princeton, N. J.

Edward R. McCarthy has been appointed general sales manager of Sorensen & Company, Inc.



Edward McCarthy (left), Helen S. Sorensen, president of Sorensen & Co., and chief engineer Leo Helterline at their booth during the recent IRE meeting in N. Y.

5-5-47

A. B. Bronwell, Northwestern University, has been elected president of the National Electronics Conference, Inc. This corporation is sponsored jointly by Illinois Institute of Tecnology, Northwestern University, AIEE, IRE and the University of Illinois, with the Chicago Technical Societies Council a cooperating organization.

W. O. Swinyard, Hazeltine Electronics, Inc., is now chairman of the board of directors.

Others elected include W. L. Everitt, University of Illinois, executive vice president; and G. H. Fett, University of Illinois, vice president in charge of programs.

Plans are now being made for the 1947 National Electronics Conference, which will be held on November 3, 4 and 5 at the Edgewater Beach Hotel, Chicago.

John N. Leedom has been appointed assistant sales manager of the Sprague Products Co., North Adams, Mass.

* * *

Clyde E. Dickey is now general sales director of Federal Telephone and Radio Corporation, Clifton, N. J.

Mr. Dickey, who has been with I. T. & T. for more than 19 years, will be in direct charge of the sales of commercial radio, rectifiers, Megatherm, wire transmission, rectifier stacks, wire and cable, tubes, transformers and crystals.

* * *

Merrill A. Trainer is now manager of RCA television equipment sales. Mr. Trainer will supervise the sale of television transmitters, studio equipment, antennas, television microwave relay equipment, etc.

* * *

LITERATURE

O'Neil-Irwin Manufacturing Co., Lake City, Minn., have released a 40-page Di-Acro catalog, No. 46-11, covering **die-less duplicating** applications.

Chemical Publishing Co., Inc., 26 Court Street, Brooklyn 2, N. Y., has issued a catalog covering books on chemistry, technology, physics, general science, mathematics, engineering, technical dictionaries, etc.

The E. F. Johnson Co., Waseca, Minn., have published data sheets covering their f-m isocoupler, phase sampling loops, filters, phase sampling transformers, tower lighting filters, supports for open-wire transmission lines, pressurized capacitors, neutralizing capacitors and high-current, high-voltage, fixed and variable inductors.

(Continued on page 63)

Variable Inductance Tuning For TV Receivers

by MYRON F. MELVIN

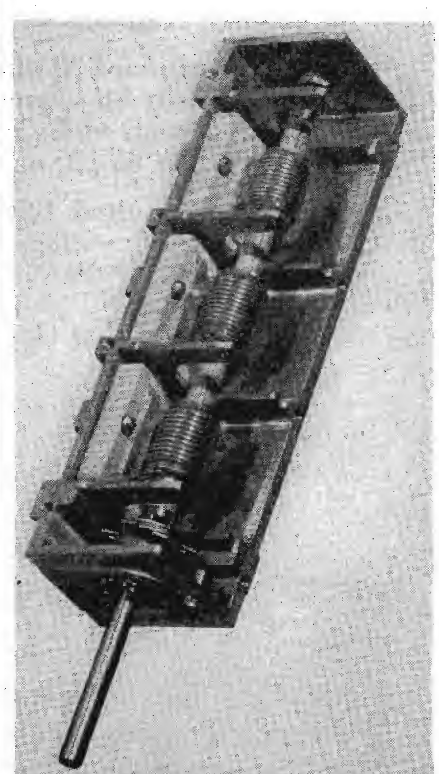
Field Engineer
P. R. Mallory and Co., Inc.

Application Data for the 44 to 216-mc Bands.

WITH THE ADVENT OF V-H-F wide-range tuning for television receivers, it has become necessary to employ other than the standard variable-capacitor method of control. In studying the problem, engineers have found that variable inductance tuning offers a solution, particularly as a basis for tuning the r-f mixer and oscillator stages.

Using the inductance-tuning procedure and applying a three-inductance type unit, shown in Figure 1,[1] many circuits can be utilized. For tv wide-pass band work, it has been found that grounded-grid amplifiers work well with the variable inductance units. Reflections can be eliminated by matching the transmission line impedance in the cathode circuit. However, in order not to exceed the recommended bias value of the tube, it is sometimes impractical to provide an absolute match to the line; but the amount of mismatch

Figure 1
The Inductuner.



is not sufficient to be discernible on the picture.

A practical means of utilizing the tuner is to allow one of the three variable inductances to serve as the oscillator variable element. The remaining two inductances may be used as the elements of a band pass circuit; the width of this can be designed for the specific application. The bandwidth can be quite broad by overcoupling the end inductors and overcoupling capacitively. An essentially constant bandwidth may be maintained over the tuning range by opposite coupling of the end inductors. Reducing the coupling, the desired selectivity can be obtained for communications-type services.

Sample Performance Data

In a variable-inductance application using a grounded-grid amplifier with one-half of a 6J6 miniature dual triode, 6AK5 converter and 6J6 oscillator with grids and plates strapped together, gain was found to be about 10, measured at the grid of the first i-f stage with the test signal fed between the cathode and ground of the grounded-grid amplifier. This value was found to be quite constant over the band of 50 to approximately 170 mc, increasing slightly at the higher frequencies. Bandwith, in this particular application, varied from 5.25 mc at a setting of 50 mc to 6 mc at 220 mc, with a maximum of 7 mc at the 150-mc setting.

Tuning-Unit Features

The tuning unit shown in Figure 1 consists of three coils mounted on a single insulated shaft. A contactor nib rides axially on a grooved, flat plate and maintains a constant contact between the coil and the plate. As the contactor slides, more or less of the coil is shorted out, effectively changing the inductance. The unused, or shorted, portion of the coil is such that its distributed capacitance resonates it above the desired frequency and prevents absorption with its resulting loss in Q.

The inductance can be varied from a value of 1 microhenry to .02 microhenry in ten turns of the shaft, or 3,600° of rotation. To limit the upper tuning range and to give the desired tracking and Q, an *end inductor* is used. The *end inductor* consists of a couple of turns of wire, self-supporting spacewound, in series with the variable element. This series inductance, with the distributed capacitance plus

[1]Inductuner; licensed under Paul Ware patents.

(*Continued on page 63*)

Audio Problems

(*Continued from page 21*)

full effect of the deemphasis curve, a requirement which remains stable until the conclusion of the record.

Since installing these equalizing amplifiers in our playback machines, we have had no complaints which could be traced to changing frequency response of our transcriptions. The inside diameter intermodulation distortion has been reduced to an average of 4%.

Other Transcription Problems

There are other problems in the recording and playback of transcriptions which will shortly be pointed up by their extensive use on f-m. Incidentally we have yet to see a transcription that will comply with the FCC requirements for f-m programs; for instance, noise level of –60 db below program level, frequency response of 30-15,000 cycles and a maximum of 3½% rms harmonic distortion. In addition, we have also noted that intermodulation due to turntable rumble, pickup unbalance, etc., is quite high on the average transcription playback table. Combined noise level of recording table, playback table and record material is generally closer to –45 db below program level rather than –60 db.

Under laboratory conditions we have been able to closely approach the extended frequency range of 30 to 15,000 cycles demanded by f-m, but not with any commercial-type equipment.

Fidelity and the Intermodulation Analyzer

During our development work we have found that the intermodulation analyzer[3] and a-f signal generator[4] are invaluable in making many major fidelity checks. For instance, distortion measurements have been facilitated to such an extent that full potentialities of amplifiers, microphones and loudspeakers could be utilized after a few minutes' test with this equipment.

In our recording department it has been possible to make comparative checks on recording heads by the simple process of recording the two reference frequencies on a given record through each head under test, and playing back and measuring the amount of intermodulation distortion present. Playbacks can be checked by a single recording played and measured by each playback under test. Of course, no one test can determine the goodness of any playback. We have found that some playbacks have excellent frequency characteristics but also a high percentage of intermodulation. By proper centering of armature in the magnetic gap, it has been found possible to reduce this figure to a reasonable level. Compression amplifiers have been checked with this method, and as a result we have been extremely careful in the use of some of them. With some amplifiers, a small adjustment allowed us to use increased com-

(*Continued on page 51*)

Broadband Radiator

(*Continued from page* 28)

tern of the antenna. The gain over a dipole calculated from this pattern is 3 db above a short dipole.

The center conductor of a 52-ohm coaxial feed cable goes to center of *6* in Figure 3 through a rather long wire which acts as a tuning inductance. This inductance in combination with the capacity across the feed point of the various metal parts and the antenna's self impedance result in 52 ohms feed impedance to match the feed cable. A shorted stub of cable (AN-RG-8/U) is also connected in shunt with the feed point. This stub is effectively $\lambda/4$ long and so appears as a very high impedance at the frequency of operation. It performs no tuning function but acts as a static drain to ground for the upper cone.

In Figure 4 appears a s-w-r curve, which illustrates the match of the antenna to the feed line. As a standing wave ratio less than 2:1 is considered a good match for this type of service it can be seen that this antenna provides an effective match in the 152 to 162-mc range. The antenna is capable of satisfactory operation over a much wider frequency range. Due to shift of the radiation pattern, the gain is slightly less at these extreme frequencies.

Ordinary accumulations of ice and snow have no measurable effect on the performance of the antenna as its broadband characteristics make it insensitive to dimensional changes.

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Audio Problems

(*Continued from page* 50)

pression without increase in distortion.

Routine maintenance tests are greatly facilitated by the use of this type equipment. Noise and distortion measurements can be made with a minimum expenditure of time.

Another interesting use of this equipment has been in checking and reducing distortion in the 50-kw transmitter. In a series of checks we were able to effect a reduction of intermodulation distortion, in some cases approximately 13%; Figure 3. This was achieved by a small readjustment of the grid circuit of the final amplifier.

[3]Altec Lansing TI-402.
[4]Altec Lansing TI-401.

Ground-Air System

(*Continued from page 26*)

final amplifier is operating properly to provide a load to the modulator.

All of the manual controls for circuit tuning and meter selection are provided at the front panel. The transmitter may be completely tuned and adjusted for circuit operation from the front of the r-f chassis. Lower power stages are adjusted by means of screwdriver adjustments. The third amplifier tank capacitor is adjusted by means of a knob attached directly to the capacitor shaft extension. A pi-network circuit adjustment for the final amplifier is indicated by two counter type indicators, one for the tuning and the second for the loading capacitor. These counters provide accurate indication of the capacitor positions. A neutralizing capacitor is also adjusted from the front panel.

Lights are provided to indicate the r-f channel and the modulator selected. A caution light is also provided to indicate when the high voltage is applied.

Modulator Circuit

The modulator circuit is fundamentally a simple audio amplifier incorporating some unique tube applications. The circuit consists of four push-pull stages, the first two being resistance coupled and the last two transformer coupled. Input from the line is controlled by means of a potentiometer which operates into a filter unit.

The low-pass filter of the modulator may be eliminated for operational requirements demanding higher fidelity. The filter unit has been designed to limit the a-f input to the modulator to frequencies below 300 cycles, in an effort to reduce adjacent channel interference caused by audio sidebands. The cut-off point is designed to attenuate 3500 cycles approximately 65 db below the response at one thousand cycles. A low-distortion modulator following the filter produces a modulated carrier that conforms to the FCC regulations for higher power equipment. In the v-h-f spectrum where broadband modulation is permissible and even desired in certain applications, the input filter may be removed. Tone control circuits or other similar circuits may then be employed.

The first and second stages of the modulator are push-pull resistance coupled 6SN7, the plate circuit of the second stage operating into a transformer which drives a pair of 807s. The push-pull 807s are triode connect-

ed and serve as drivers for the modulator tubes. The modulator tubes are two 813s, also connected as triodes.

To provide a low distortion modulator, it is necessary to provide a driver stage that has adequate power capabilities as well as excellent regulation. The regulation factor is more difficult to obtain than the power. The foregoing assumes that the grids of the modulator are driven to current conditions or approximately to current conditions. Under these conditions, the grid impedance shifts considerably and severe distortion may occur if adequate regulation of the driving circuit is not provided. The ideal method of obtaining good regulation is to provide a very low resistance and low impedance circuit. The 807s, while offering a large reserve of power, also provide a very low-impedance tube when connected as a triode, by placing the screen and plate together. The curves on this tube, connected as a triode, indicate an impedance of approximately 800 ohms. The screen and plate dissipation are found to be well below rating.

The successful operation of the 807 as a triode gave the lead toward operating the 813 as a triode. Connecting the plate and screen together was not practical because of the high plate voltages and normally low screen voltages required of this tube. The screen was therefore connected to the grid, the suppressor grid being grounded. After complete measurements were made on the tube, it was found that the bias voltage supply could be replaced with a cathode or heater return bias resistor. This resistor developed the required voltage without an increase in the distortion level of the amplifier. The elimination of the bias supply reduced the space requirements of the unit.

Complete distortion measurements on the modulator unit when operating into the r-f vacuum tube load have shown the distortion to be below 5%. This figure represents the total harmonic distortion when measured by means of a wave analyzer. The arithmetical sum of all harmonics to the sixteenth was included. A check with a noise and distortion meter indicated a distortion of approximately 2.5%; the noise and distortion meter is a device that measures the algebraic sum of the harmonics and thus will, in general, record approximately one-half that noted by the wave analyzer.

All air required for the transmitter is drawn in through the rear of the cabinet through ducts and filters. Each blower provides approximately 600

(*Continued on page 54*)

Ground-Air System

(Continued from page 53)

cubic feet per minute air flow which is distributed to various points within the cabinet.

The meters for the transmitter are mounted across the top of the cabinet. The line voltage and audio level input is recorded by one meter, the particular function being selected by means of the selector switch on the control panel. All currents in the transmitter are recorded by means of a meter switch on the front of the given r-f unit. The r-f unit being measured is selected by means of a switch on the control panel.

The antenna terminals of the transmitter are contained in a well in the top of the cabinet. This well provides a screen air outlet for forced air cooling of the transmitter as well as protective recess for the antenna terminals.

For remote installations, the transmitter may be located several miles from the operator's position. Complete control, including channel selection, type of operation, and starting and stopping the unit is possible from the operator's position. Two telephone lines may be employed, allowing two operators to transmit, simultaneously, on two frequencies. These may be either telephone or c-w transmissions. Another possible combination allows one operator to operate any one of the four r-f units as either telephone or c-w transmitters. Other combinations possible allow complete elimination of the telephone lines by use of v-h-f radio links.

A fourth type r-f head for the 152-162 mc f-m band is in development; this will also fit the standard space provided. All electrical connections will be identical with the other three units.

With the f-m channel the transmitter will be suitable as a fixed station for multi-channel communication with mobile units such as taxicabs. The f-m channel could also serve as a means of communication with emergency vehicles, with three high-frequencied channels used for operations on a nation-wide police c-w network.

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NOBLE RECEIVES IRE FELLOWSHIP

D. E. Noble (center), vice president in charge of the communications and electronics division of Motorola, receiving IRE fellowship diploma from Dr. W. R. G. Baker, president of IRE, while FCC chairman Charles R. Denny looks on.

Paper-Disc Recorder

(*Continued from page 32*)

possible to provide guide grooves in the paper blanks, it was decided to use a spirally-groved plastic tracking disc. As finally developed, the disc is 5⅛" in diameter, with a hole to fit an indexing pin.

A guide stylus, on the tone arm which holds the recording-reproducing head, was placed in the spiral groove to guide the tone arm so that the magnetic head would always trace out the same path on the exposed portion of the recording blank.

For slight variations in tracking from one instrument to another a *tuner* knob was placed on the tone arm. The guide stylus was mounted eccentrically on the shaft which terminates in this knob. Thus rotating the *tuner* knob moves the arm relative to the grooved *tracking* disc, and permits the magnetic head to be centered directly over the sound track.

The unit provides for the making of recordings from the inside out, because of the much greater certainty with which the starting point can be determined at the inside edge. To operate, the tone arm is lifted slightly off the recording blank and moved in to the center as far as it will go. Releasing then automatically places the arm in the innermost portion of the sound track.

The turntable (9") was designed to rotate at 20 rpm. This provided a lineal speed of the medium beneath the recording head of 5.7 inches per second at the inner edge of the exposed portion, increasing to 9.4 inches per second at the outer edge. Such low speeds for a magnetic recording medium were unheard of only a few years ago. Poulsen's original magnetic recorder, built about 1900, used piano wire as the recording medium which had to be run at a speed of 10 feet per second to get acceptable voice quality.

Another factor that required close study, during the design of this unit, was the coercivity of the material used in recording blanks. Coercivity, a measure of the force with which it resists demagnetization, also indicates the extent to which variations in magnetism can be crowded together on the medium without influencing each other, or in other words, the *fineness of resolution* of the medium. The higher the coercivity of a magnetic recording medium, the greater is the quantity of recording that can be crowded into a given space.

To permit the discs to run at low speeds, high coercivity material was therefore chosen. This same property

(*Continued on page 56*)

(Continued from page 55)

also makes it possible to record forty sound tracks side by side in an inch-wide strip of the medium without cross-talk. The width of the sound track is .014″; in other words, the sound tracks are separated from each other by only .011″.

The figure of forty sound tracks per inch was arrived at on the basis of cross-talk studies which were made on powder-coated media. A single sound track was recorded on coated tape, and the playback level measured when the reproducing head was directly over the sound track, and when it was displaced laterally by successively larger amounts. The family of curves in Figure 3 shows the playback level at different displacements and frequencies for a tape speed of 6″ per second. From these curves it will be noted that for a 100-cycle signal the output of the reproducing head will be 13-db higher when the head is directly over the sound track, than when it is displaced 0.02″ to either side of the sound track.

These curves also reveal the relationship of cross-talk to frequency; the lower the recorded frequency, the more the reproducing head must be displaced laterally to secure a given reduction in level. The paper-disc playback-recorder was designed exclusively for the speech range, and so the very low frequencies can be dispensed with entirely. This results in no loss in intelligibility, and permits the sound tracks to be spaced much closer together than would be possible if music were being recorded. The frequency response of the unit is, as a matter of fact, about the same as that of a telephone. With the magnetic head properly centered over the sound track, no cross-talk can be detected.

Somewhat closer spacing of the sound tracks would be permissible if cross-talk was the only criterion. Satisfactory operation has been obtained with a spacing of sixty sound tracks to the inch. For such close spacing, however, indexing the record becomes critical when it is removed and subsequently replaced. By using a spacing of forty tracks to the inch the indexing of the record becomes substantially foolproof, and variations of the dimensions of the record with age and climatic conditions become of negligible importance.

Dual-Purpose Crystal Phone

A single crystal phone was included in the unit to serve as recording microphone and playback earphone. Its voltage output as a microphone is high, and it was found necessary to use only one amplifier stage, V_2, between it and

output tube, V_3, which supplies recording current to magnetic head; Figure 4. A supersonic bias current, used in recording, is generated by an oscillator tube, V_4, and fed to the magnetic head in parallel with the signal current from V_3.

Mixed bias and signal currents flowing through the coil of the magnetic head produce a varying magnetic field across the gap in the pole pieces. This gap rests directly on the surface of the moving recording blank and the varying magnetic field locally magnetizes the coating of the blank to a degree proportional to the instantaneous strength of the signal current.

In the playback process the magnetic head retraces the same path over the blank, and magnetic variations along this path generate a voltage in the coil, corresponding to the original signal. Amplified by V_1 and V_2, this voltage is supplied to the grid of the output amplifier, V_3, which drives the crystal phone to supply an audible signal.

To achieve the minimum possible noise level, it is essential that no remanent magnetization exist in the polepieces of the recording head. In practice, this is a somewhat difficult condition to achieve. Although the polepieces are specially heat-treated to yield the magnetically softest possible material, minute strains set up in the assembly process tend to counteract the effect of the heat treatment, and render the polepieces slightly susceptible to stray magnetic fields.

To overcome this difficulty the head was placed in a circuit which provided automatic demagnetization every time a switch was thrown to a play position. This was accomplished by the inclusion of a capacitor in the circuit.

In operation the capacitor is charged up during the operation of the instrument. When the switch is thrown from *record* to *play* capacitor discharges through oscillator tube, generating a damped sine-wave which is applied to the coils of the magnetic head. This decaying a-c field effectively demagnetizes the polepieces each time it is applied to them, removing any slight remanent magnetism which might exist. Thus every time the switch is thrown the magnetic head is neutralized. This procedure also provided an improvement in the signal-to-noise ratio.

To provide maximum use of the disc, a *pause* switch was included in the unit; this can be used to interrupt a recording momentarily while the operator decides on the next word or phrase. As long as this switch is held in the *pause* position, the turntable will

(*Continued on page* 58)

Lateral Recording

(*Continued from page* 40)

the surface of the disc and adjust the angle of the head until the cutting edge of the stylus makes a straight line with its reflection in the disc. In this position, the stylus is vertical with the disc surface. With some stylus points and discs, it may be necessary to set the angle of the cutting edge with the disc at slightly less than 90°. While the angle, which gives the quietest groove, must never under any conditions exceed 90°, it may vary with discs and styli from 90° to a minimum of 85°.

The depth of the groove is an important element in the cutting of a good record. Too deep a cut will cause echo due to heavy modulation level, causing the walls of adjacent grooves to be distorted by modulation in the preceding or following grooves. Too light a cut or too shallow a groove will result in the inability of some playbacks to track properly.

[To be continued]

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Paper-Disc Recorder

(*Continued from page* 57)

not revolve, and no recording time is wasted.

In common with all magnetic recordings, the disc blanks can be played back many times without appreciable loss of volume or quality. Heat, cold, and wide variations of humidity have no effect on them, and they can be stored indefinitely for long periods.

A blank on which a recording has been made can be erased at any time by rotating it beneath a special bar magnet.

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TV STUDIO RECEIVER

Television studio-type receiver, recently designed by General Electric, being demonstrated by Philip G. Caldwell, G. E. tv equipment sales manager, during a tv broadcasting conference at the Syracuse plant of G. E. Left to right, G. E. field men, W. C. Jaeger, Boston; S. W. Pozgay, Chicago; and M. F. Chapin, Minneapolis.

The Industry Offers

(*Continued from page* 44)

15,000 cycles and less than 1% total distortion over the range 30-15,000 cycles; as a monitor amplifier, +39 dbm (8 watts) with less than 1% total rms harmonic distortion over the range 50-10,000 cycles. Output noise equivalent to an input signal of —120 dbm over a bandwidth of 20,000 cycles.

Input source impedance and output load impedance same as 116-A.

Uses two 1620 and two 6V6GT.

* * *

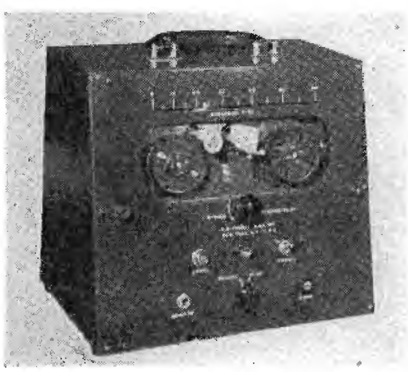
WIRECORDER UNITS

First of five wire recording models, model B, has been announced by The Wirecorder Corporation, Detroit, Mich.

Recorder is said to be interchangeable with most sound-on-disc and sound-on-film recording equipment and usable with any suitable amplifying system already in operation.

Features of recorder include a capstan drive, magnetic clutches to keep wire tension constant during recording, cam-operated recording head to wind the wire in even layers on takeup spool, and safety switches to stop the motor when a spool is almost entirely unwound.

Wirecorder Corp. is represented by R. C. Powell and Co., New York City.



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KEITHLEY SIGNAL DIVIDER

A signal divider (model 101) to provide low level input signals used in testing high gain amplifiers has been designed by Keithley Instruments, 1508 Crawford Road, Cleveland 6, Ohio. Signal divider attenuates in decade steps, and is used in conjunction with the output control of the signal source.

The circuit is a resistance potentiometer with one side grounded.

In operation, the input is connected to a source of test signal, and the output to the circuit under test. Terminals are provided for connecting a monitoring voltmeter in parallel with the input. Test voltages are obtained by setting the test oscillator output to a value between one and ten volts, which is a multiple of 10 greater than the desired voltage, and then setting divider to reduce the oscillator voltage by the correct multiple of 10.

Signal divider also said to feature a comparatively wide frequency range and an input impedance of 11,000 ohms.

Output voltages available from ten microvolts with 0.1 volt input, to 100 volts with 100 volts input. Frequency range is 0 to 200,000 cps.

* * *

JFD TEST LEADS

A line of test leads and test lead accessories has been produced by the JFD Manufacturing Co., 4117 Fort Hamilton Parkway, Brooklyn 19, New York. Test leads use fiber and cast phenolic prod handles, and are made of No. 18 soft-drawn copper. End fittings (phone tip, phono needle point, spade lugs, alligator clip, banana plug, and elbow angle tips) are of chromium-plated brass.

* * *

GUARDIAN ELECTRIC MIDGET RELAY

A relay comprised of two basic parts, a coil assembly and a contact assembly (series 600), with basic part interchangeable, has been announced by Guardian Electric Mfg. Co., Dept. 600, 1623 West Walnut Street, Chicago 12, Illinois. Contact assembly can be used with any of the series 600 or 605 coils whether the

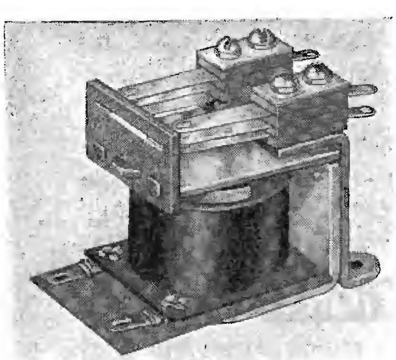
(*Continued on page* 60)

The Industry Offers

(*Continued from page 59*)

operating voltage is 3, 6, 12, 18, 24, 32, 50, 115, 230 a-c or 3, 6, 12, 18, 24, 32, 50, 110 d-c. Maximum contact current capacity is 8 amperes and power consumption is 6 va.

Relay can be furnished with many contact switch combinations up to and including four-pole, double-throw.



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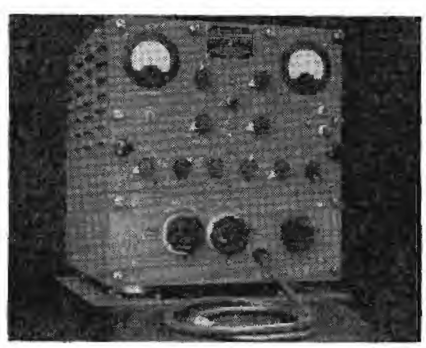
GENERAL COMMUNICATION U-H-F SIGNAL GENERATOR

An u-h-f signal generator, designed to furnish an r-f signal for calibration and alignment of u-h-f receivers, and for general laboratory work within the range of 1,200 to 4,000 mc (model P142), has been developed by the General Communication Co., Boston, Mass. Provides unmodulated, pulse modulated, or f-m signal.

A bolometer with indicating meter is provided so that the r-f output level of the unit may be checked continuously. As this monitoring level varies in amplitude, a calibration curve is provided to compensate for this variation. The monitoring level is also frequency



selective and another calibration curve is provided to compensate for this frequency error.

Oscillator is a velocity-variation reflex type using an adjustable cavity. One control is used for setting cavity length and another is provided for accurately setting the repeller voltage in order to peak the oscillator tube to the desired mode.

Absorption type wavemeter is used in conjunction with a crystal detector and level indicating microammeter.

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HICKOK VOLT-OHM-CAPACITY-MILLIAMMETER

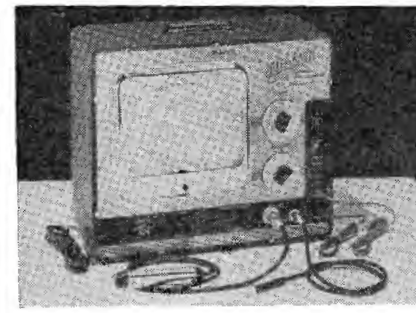
An electronic volt-ohm-capacity-milliammeter, model 209, with a low capacity, high-frequency probe has been developed by the Hickok Electrical Instrument Co., 10529 Dupont Avenue, Cleveland 8, Ohio.

Unit measures d-c voltages across avc discriminator and limiter circuits (d-c circuit rejects all a-c voltages). Polarity reversing switch permits use on d-c without changing lead connections.

Ranges: volts (a-c or d-c and ma), d-c, 0-3, 12, 30, 120, 300, 1,200; capacity, 1-10,000 mmfd in 2 ranges, and 1-1,000 mfd in 5 ranges; inductance, 50 mh-100 henries (using conversion chart); resistance, 1/10 to 10,000 megohms in 8 ranges.

Input impedance (volts a-c): 12 megohms shunted by 6 mmfd; (volts d-c) 15 megohms.

Tubes used include two 6X5GT (rectifiers); one 6SJ7 (cathode follower); one 6SN7GT (vacuum-tube voltmeter); one OD 3/VR 150 (voltage regulator), and one 9006.



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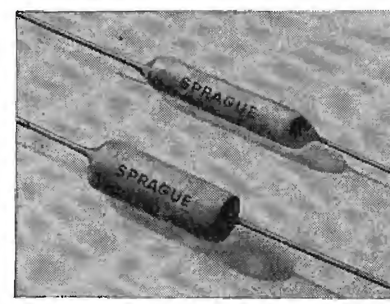
SPRAGUE MINIATURE CAPACITORS

Miniature capacitors in round and flat types, types 63P and 64P, have been announced by the Sprague Electric Company, North Adams, Mass. Standard units available include capacities ranging from .00025 to 1 mfd; typical capacitor rated .005 mfd at 150 volts is ¾" long x 3/16" diameter.



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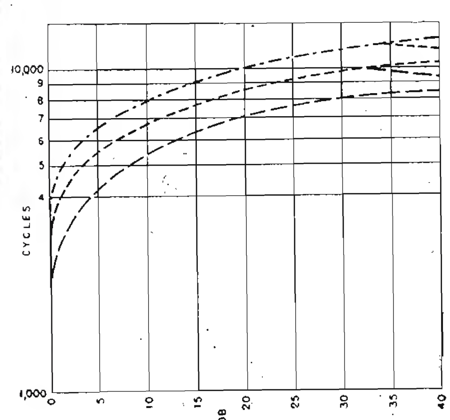
BURNELL SCRATCH FILTER

A scratch filter featuring a flat response within the bass band and sharp attenuation above cutoff frequencies has been developed by Burnell & Co., 45 Warburton Ave., Yonkers 2, New York.

Three cutoff frequencies are provided via a single-circuit switch.



* * *

RCA GERMANIUM CRYSTAL PROBE

A miniature germanium crystal rectifying probe, which adapts the voltohmyst and chanalyst for tv, f-m and other v-h-f circuit testing has been developed by the test and measuring section of the RCA engineering products department.

The probe (type MI-8263) employs the crystal to rectify applied a-c voltages which are then measured by the d-c circuit of the meter; meter reading is proportional to the positive peak of the applied a-c voltage.

* * *

WHEELER LAB R-F INDUCTANCE METER

A direct-reading inductance meter for measuring inductance at the radio frequencies of nor-

mal operation has been developed by the Wheeler Laboratories, Inc., Great Neck, New York. In five decades it covers continuously the ranges of 1μh to 100 mh; values of inductance are read directly from the linear scale of a standard variable capacitor with the decimal point being determined by a proper multiplier.

Instrument can also be used for direct measurement of small capacitance (up to 1,000 mmfd) and for indirect measurement of larger capacitance.

Inductance range: Decade 1, 0 to 10 μh, 1,600 to 1,100 kc; 2, 0 to 100 μh, 500 to 350 kc; 3, 0 to 1 mh, 160 to 110 kc; 4, 0 to 10 mh, 50 to 35 kc; and 5, 0 to 100 mh, 16 to 11 kc.

* * *

TRIPLETT VOLT-OHM-MILLIAMMETER

A high-impedance volt-ohm-milliammeter, model 2450, has been announced by the Triplett Electrical Instrument Co., Bluffton, Ohio.

Instrument uses two voltage regulator tubes. Ranges are: D-c volts, 0-2.5-10-50-250-500-1,000; a-c volts, 0-2.5-10-50-250-500-1,000; d-c milliamps, 0-0.1-1.0-10-50-250-1,000; ohms, 0-1,000 (midscale 10)-10,000-100,000; megohms, 0-1-10-100-1,000; and capacity in mfd, 0-.05-.5-5-50-500.

* * *

SIMPSON ILLUMINATED METERS

Illuminated meters in 2" and 3" sizes, and in rectangular and round cases, have been developed by the Simpson Electric Company, Chicago, Illinois.

A patented method of illumination is used with a lucite cone carrying the light from a recessed bulb in the back of the instrument through the front edge of the cone which entirely surrounds the dial face. This makes possible the use of a standard metal dial.

* * *

RCA BATTERIES

Four new types of batteries have been announced by RCA.

Batteries range from a baby flashlight cell and a penlight cell to a lantern battery; 1½-volt-baby flashlight cell (type No. VSO33), 1" in diameter by 1⅞" long; penlight cell (type No. VSO34), also 1½ volts, 9/16" by 1 15/16"; 1½-volt ignition cell (type VSO061S), 2⅝" by 6 9/16"; and 6-volt lantern battery (type VSO40), 2⅝"x2⅝"x4".

F-M LOOP ANTENNAS

(*Continued from page 35*)

version transformer would have to be employed. Measurements made on the circular antenna, comparing the results obtained by feeding it directly with a coaxial line, grounding one of the terminals, and feeding it with a conversion transformer indicated that there is no practical need for including the transformer in the circuit.[4] Hence, one terminal of the input leads is grounded, dotted in Figure 3*c*, when a coaxial feed line is employed. With one terminal grounded, horizontal pattern measurements showed no evidence of redistribution of the currents in the important radiating elements.

In studying the final antenna we find that the double current path serves two purposes. First, it permits a transformation of the radiation resistance to a terminal resistance value in the general order of the nominal characteristic impedance of the coaxial transmission lines used to feed the antenna. Second, it permits direct mounting of the radiating system at a point of ground potential so that the disturbing capacity effects, which normally accompany insulated mountings, are eliminated and protection against lightning is secured. The adjustable capacitor permits tuning of the electrical circuit to resonance at the factory to the desired frequency of operation. An experimental horizontal pattern is illustrated in Figure 5.

The Square Loop F-M Antenna

The square loop f-m antenna is based on the u-h-f loop antenna developed for blind landing systems.[5] The basic operating principle is illustrated in Figure 6. Two small loops, small enough so that the current is quite uniform, are fed in the phase indicated on the figure by the plus and minus signs. Both plus terminals and both minus terminals are in the same phase. The loops are semi-circular and placed back to back as shown. The current in the leg *BC* will cancel the current in the leg *FE*. Hence points *B* and *F* and points *C* and *E* can be solidly connected.

This type of loop antenna can be fed by a coaxial line in the manner of a shielded loop wherein the shield is the antenna and the coaxial line runs up through the shield. This is illustrated in Figure 7. It is called a two-

[4] A. G. Sheldorf, *Circular Antennas*, Sixth Annual Conference of Broadcast Engineers, Columbus, Ohio; COMMUNICATIONS, April, 1946.

[5] A. Alford and A. G. Kandoian, *UHF Loop Antennas*, AIEE Transactions Supplement, p. 843; vol. 59, 1940.

Figure 10
The measured horizontal radiation pattern of the loop shown in Figure 9. (*Courtesy FTR*)

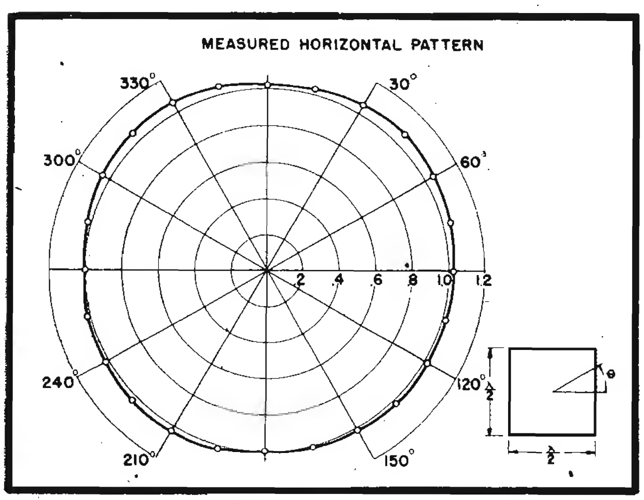
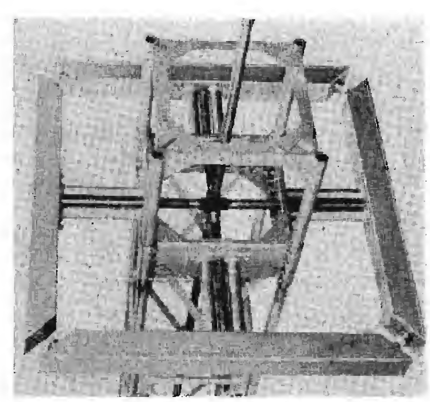


Figure 9
Constructional details of the square f-m loop, a modification of the loop shown in Figure 8(*b*). (*Courtesy FTR*)



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element loop and its circumference cannot exceed one wavelength. To increase the size of the loop, more elements are added. Figure 8 shows the schematic diagrams of the three- and four-element loops. The circumference can be increased a half wavelength for each added element.

In the final design a four-element loop was chosen and, since the electrical characteristics of a loop do not vary as the shape is varied within reasonable limits, a square construction was employed. This is illustrated in Figure 9. The lines coupling the main feeder to the radiating elements are used as the matching device to match the antenna to the characteristic impedance of the feed line.

It was found that the same sized mechanical structure could be used for any frequency in the f-m band. The measured radiation pattern of the final antenna is shown in Figure 10.

[To be continued]

Variable Inductance Tuning

(*Continued from page* 49)

the lead inductance, determines the upper frequency to be selected. As can be seen, the spacewound fixed inductance will have a higher Q than the portion of the last turn of the tuner. This causes the Q to rise as the upper frequency limit is approached.

Special alloys of wire, *trolley guides,* and end rings, in conjunction with the nib contactor aid in reducing the tuner noise to a level below that of the tube noise.

The problem of reset error, or resetability, is a serious one in high-frequency circuits. Therefore the tuner has been designed for a maximum reset error of .025% or 100 kc at 200 mc, making it possible to use the unit in conjunction with a motor drive or mechanical pushbutton arrangement.

News Briefs

(*Continued from page* 47)

Sylvania Electric Products, Inc., Emporium, Pa., has released a 378-page technical manual containing basic application data for 545 types of receiving tubes used by circuit designers, radio set repairmen and industrial electronic engineers.

Data supplied includes characteristic curves for types in common use; resistance-coupled amplifier data; interchangeable tube charts; connections for standard RMA internal and external shields; typical receiver and amplifier circuits; dictionary of tube, circuit and f-m terms; and instruction on the use of characteristic curves.

Priced at eighty-five cents, manuals are available from Sylvania distributors or from Sylvania Electric, Emporium, Pa.

Andrew Co., 363 East 75 Street, Chicago, Ill., has released folders and magazine reprints covering folded unipole and quadrupole antennas.

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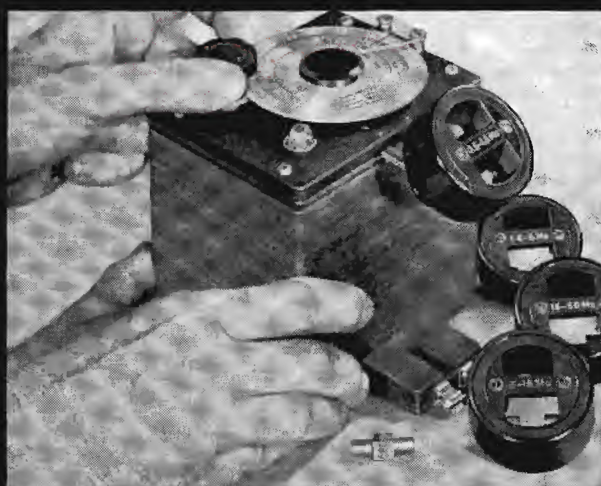
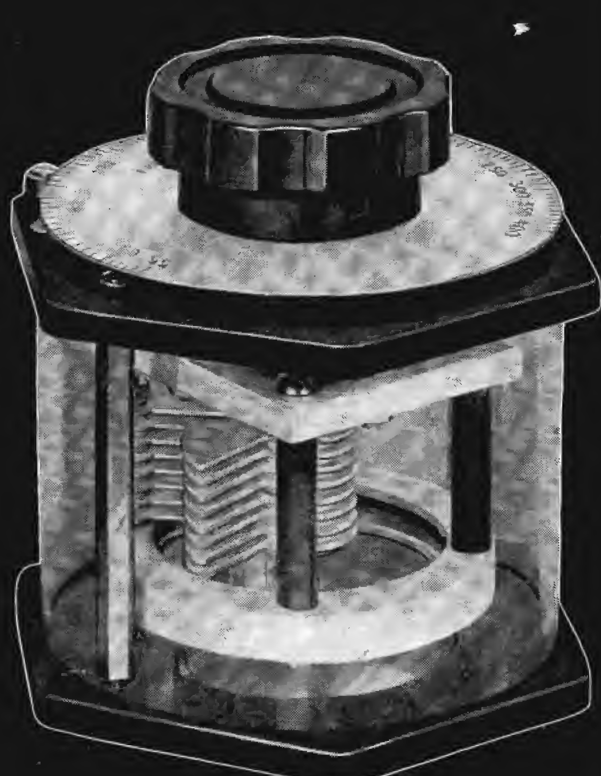


TYPE 566-A — 0.5 to 150 Mc



TYPE 758-A — 55 to 400 Mc

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Both are of the well-known absorption type with accuracies sufficient for a wide variety of routine frequency checks on the ranges of coils, oscillators, receivers, transmitters, etc.

The Type 566-A Wavemeter consists of a variable air condenser, five plug-in coils and an incandescent lamp for resonance indication. The Type 758-A Wavemeter covers its entire frequency range with a single-turn loop the inductance of which is varied simultaneously with the capacitance. An incandescent lamp is used for resonance indication. For low power uses (less than about 2 watts), resonance indication is obtained by the reaction of the wavemeters on the plate or grid currents of the oscillator.

These wavemeters are compact, rugged, inexpensive and direct reading in terms of our primary standard of frequency.

TYPE 566-A WAVEMETER

FREQUENCY RANGE: 0.5 to 150 Mc
COILS: Five plug-in type, all supplied. When not in use coils can be plugged into a rack on side of the instrument case
DIAL CALIBRATION: Direct reading in frequency
ACCURACY: ±2%, 0.5 to 16 Mc; ±3%, 16 Mc to 150 Mc
RESONANCE INDICATOR: Incandescent lamp
ACCESSORIES SUPPLIED: Two spare indicator lamps
DIMENSIONS: 4¾ x 5⅞ x 5¾ inches, over-all
WEIGHT: 3 pounds
PRICE: Type 566-A WAVEMETER — $60.00

TYPE 758-A WAVEMETER

FREQUENCY RANGE: 55 to 400 Mc
COILS: A single turn loop; inductance and capacitance are varied simultaneously
DIAL CALIBRATION: Direct reading in frequency
ACCURACY: ±2%
RESONANCE INDICATOR: Incandescent lamp
TEMPERATURE AND HUMIDITY: Over ranges normally encountered, accuracy is independent of both
DIMENSIONS: 5 x 5 x 4¾ inches, over-all
WEIGHT: 1 pound, 12 ounces
PRICE: Type 758-A WAVEMETER — $35.00

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